REPORT OF

JOINT ARMY - NAVY BOARD
ON
AN ADDITIONAL CROSSING
OF
SAN FRANCISCO BAY

PRESIDIO OF SAN FRANCISCO, CALIFORNIA

JANUARY 25, 1947

(Without Appendices)

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OF SAN FRANCISCO BAY

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OF SAN FRANCISCO BAY

San Francisco, California,
January 25, 1947.

SYLLABUS

The Joint Board of Army and Navy Officers appointed to report upon an additional crossing of San Francisco Bay pursuant to House Resolution 529, 79th Congress, 2nd Session, concludes that the best solution to the cross-bay transportation problem is to provide for:

a. The immediate construction of a six-lane combination open causeway-tube from the vicinity of Army St. in San Francisco to the vicinity of 5th St. in Alameda with a four-lane extension under the Oakland Estuary to the proposed East Shore Freeway, and;

b. The development of an electric rapid-transit system for mass transportation carried across the bay in a centrally located subaqueous tube devoted solely to that type of traffic.

PART A

I. AUTHORITY AND BACKGROUND

1. This report is submitted pursuant to the above-mentioned resolution which reads in part as follows: "Resolved, that the Secretary of War and the Secretary of the Navy are requested to review their report submitted to Congress in response to House Resolution 158, 77th Congress, first session, for the purpose of investigating and reporting upon the need and feasibility, from the standpoint of the national defense and the development of peacetime economy, of constructing a bridge from San Francisco to Bay Farm Island, or a system of dams across San Francisco Bay as provided for in the so-called Reber Plan,

and to be forwarded to the Congress as soon as practicable by the Secretary of War and the Secretary of the Navy who are further requested to transmit therewith their recommendations in the premises."

2. The Joint Army and Navy Board was appointed by a joint letter from the Secretaries of War and Navy dated May 10, 1946, and was comprised of the following members:

ARMY MEMBERS

Brigadier General Garrison H. Davidson, AUS, Senior Member
Colonel Edwin H. Marks, CE, USA
Colonel George Mayo, CE, USA

NAVY MEMBERS

Commodore Lewis N. Moeller, CEC, USN
Captain F. C. Fluegel, USN
Captain James E. Baker, USN

3. It was directed to hold hearings, conduct interviews, and make personal inspections of sites as deemed necessary for carrying out its mission. That part of the investigation wherein the interests and views of the public were presented were conducted in open sessions.

4. The efforts of the Board were directed toward:

"(a) Determining whether a need exists, from the standpoint of the national defense and/or the development of peacetime economy, for another crossing of San Francisco Bay, or a system of dams across San Francisco Bay, and if needed:

"(b) Determining the feasibility of such construction, and

"(c) Recommending the solution to the cross-bay transportation problem that will best meet this need with minimum potential interference with military and/or commercial operations in peace and in war."

5. The report of the Board is accompanied by a complete statement of the considerations governing its conclusions, and has been considered

and so be forwarded to the Congress as soon as practicable by the Secretary of War and the Secretary of the Navy who are further directed to transmit therewith their recommendations in the premises.

2. The Joint Army and Navy Board was organized by a joint letter from the Secretaries of War and Navy dated May 27, 1943, and was composed of the following members:

Army members

Brigadier General Dwight D. Eisenhower, USA, Deputy Chief of Staff
Major General Leslie R. Groves, USA
Rear Admiral Ralph A. Ofstie, USN

Navy members

Commodore Lewis L. Strauss, USN, Aide
Captain J. C. Hunsaker, USN
Captain Lloyd S. Adams, USN

3. It was directed to hold hearings, receive testimony, and make personal inspections of plants as deemed necessary in carrying out the mission. Some part of the investigations which were interrupted and where of the results were presented were conducted in open session.

4. The efforts of the Board were directed towards:

"(a) Determining whether a need exists, from the standpoint of the National Defense, for the development of practicable means for the storage of the Pacific Ocean, or a portion of some ocean, for the storage of the Pacific Ocean, or a portion of some ocean, and if needed;

"(b) Determining the feasibility of such construction, and

"(c) Determining the relation to the over-all transportation problem that will have such item and its relative potential importance with military and/or commercial operations in peace and in war."

5. The report of the Board is accompanied by a complete statement of the considerations governing its conclusions, and has been submitted

as CONFIDENTIAL as directed by the precept.

II. SUMMARY OF PREVIOUS REPORTS.

1. The Board reviewed previous reports on the subject, including that of the commission which was appointed in accordance with instructions from the President of the United States and the Governor of the State of California in 1929 to endeavor to work out a solution of the State and interurban traffic needs between the counties of San Francisco and Alameda across San Francisco Bay.

2. This commission became known as the Hoover-Young San Francisco Bay Bridge Commission. It concluded that the traffic needs required a crossing located on a relatively direct line between the centers of automobile and commuter traffic demand and that it should carry automobile and interurban traffic. It gave principal consideration to five possible locations for a crossing, and finally recommended the general location where the present high-level bridge is situated.

3. Pertinent extracts from the conclusions of the report submitted to Congress in response to House Resolution 158, 77th Congress, first session, which this Board has been directed to review are:

"(a) It is feasible to construct a bridge between Hunter Point and Bay Farm Island.

"(b) Either a high-level or a reasonably low-level bridge can be constructed.

"(c) The estimated cost of a high-level bridge is approximately $53,200,000; and of a low-level bridge, approximately $55,800,000.

"(d) The bridge, if constructed, should be a double-deck bridge, with at least four traffic lanes on the upper deck with provision for physical separation of opposing traffic and two lanes for truck

traffic and two railway tracks on the lower deck, with suitable approaches at each end, connecting with respective highway and railroad facilities.

"(e) A high-level bridge in its main channel span should provide an unobstructed horizontal clearance of at least 1,000 feet and a vertical clearance above mean higher high water equal to the maximum provided by the existing San Francisco - Oakland Bay Bridge (214 feet).

"A low-level bridge should provide in its crossing of the main bay channel an unobstructed horizontal clearance of at least 450 feet and vertical clearance of 70 feet above mean higher high water when the vertical lift span is closed and 140 feet with the lift section fully raised.

"(f) If built, the bridge should preferably be a high-level type.

* * *

"(i) A bridge between Hunter Point and Bay Farm Island would adversely affect naval operations and the defense of naval establishments in the vicinity.

"(j) From the standpoint of the national defense, there is no present or immediately prospective need for a bridge across San Francisco Bay between Hunter Point and Bay Farm Island."

4. The report recommended that:

"(a) No bridge can be constructed across San Francisco Bay between Hunter Point and Bay Farm Island at the present time on the basis of requirements of the national defense.

"(b) If, however, the construction of a bridge between Hunter Point and Bay Farm Island is authorized, the Board recommends that the type, characteristics, and dimensions thereof be in accordance with its conclusions stated in the preceding paragraph."

III. CONCLUSIONS

1. The solution to the cross-bay transportation problem should be that plan which will provide for the greatest benefit to the entire Bay area considered as an economic entity and which will give reasonable protection to the national interests.

2. While an additional crossing for any type of traffic is not necessary at this time from the standpoint of the national defense, additional crossing facilities for San Francisco Bay for automobile (passenger, truck and bus) traffic are desirable now and will be necessary from the standpoint of the peacetime economy by the time another crossing can be provided.

3. The best solution to the cross-bay transportation problem in its entirety is a plan combining the existing bridge, a second vehicular crossing, and a system of rapid mass transportation, including a cross-bay subaqueous tube, to provide for all cross-bay traffic over an extended period of years.

4. While much of the cross-bay commuting public should be induced to change its traveling habits, it will not be so induced until suitable and completely integrated rapid transit facilities are provided in the East Bay communities and in San Francisco. The immediate solution should provide for automotive vehicular (including trucks and buses) traffic only. Ultimately, however, congestion on the streets of San Francisco will force the bay area to increase the use of mass transportation, and the comprehensive solution should recognize this eventuality.

5. Additional interurban railroad facilities, as presently operated, are not necessary at this time.

6. It is impracticable, if not impossible, to provide a single acceptable type of crossing which will meet the necessity of, and the desires for, automotive vehicular, interurban, and main-line railroad traffic. Therefore, the next crossing should not include provisions for carrying main line railroads.

7. A crossing at the locations reported on to Congress in response to House Resolution 158, 77th Congress, First Session, namely, from Hunter Point to Bay Farm Island, would not solve the present problem.

8. A continuous low level bridge with draw or lift span located northerly of Hunter Point is definitely objectionable from the standpoint of water-borne and highway traffic as well as national defense, and a continuous causeway with locks located within the limits prescribed for the Board's study, or within a reasonable distance therefrom, is untenable from the standpoint of navigation and national defense.

9. The Reber Plan would result in a dislocation of industry, is considered economically infeasible, and further, is untenable from the standpoint of navigation and national interests.

10. The central business district of San Francisco could not absorb the ultimate volume of traffic that would be introduced by a second crossing, so regardless of where the latter is located, parking facilities adequate to absorb a large portion of the cross-bay traffic before it enters the district should be provided.

11. None of the terminal areas in San Francisco offer a street pattern, even when improved within practical limits, that could absorb at a maximum more than 4 additional lanes of cross-bay traffic in each direction. It is felt that further detailed study by the local

construction agencies may indicate that none of the terminal areas in San Francisco offer a street pattern, even when improved within practical limits, that could absorb more than 3 additional lanes of cross-bay traffic in each direction.

12. As a result of the Board's study, a second bay crossing consisting of a 6-lane open causeway-tube from the vicinity of Army Street in San Francisco to the vicinity of 5th Street in Alameda, with a 4-lane extension under the Oakland Estuary to the proposed East Shore Freeway, is the logical component of an overall plan and, based upon available traffic data, will solve the cross-bay vehicular traffic problem.

13. This proposed crossing should be complemented in San Francisco by a freeway for bringing cross-bay traffic from the crossing to, and beyond, the Southern Pacific and other railroad tracks south of Townsend Street and dispersing it properly.

14. This proposed crossing is practicable from an engineering standpoint. It is economically feasible, and even though the tangible economic considerations favor a central high-level bridge crossing, the intangible benefits resulting from the construction of the causeway-tube greatly outweigh the advantages of a central high-level bridge.

15. A main bay channel of at least 1,500 feet clear width, with a minimum depth of 50 feet below mean lower low water and adjoining secondary channels with clear widths of about 800 feet and 20 feet minimum depths, should be provided.

16. Ventilating towers of the tube should not exceed elevation 125 feet above mean lower low water.

17. Concrete planning for the development of an electric rapid-transit system for mass transportation, replacing facilities on the existing bridge and carried across the bay in a centrally located sub-aqueous tube devoted solely to that type of traffic, should be started now so that the comprehensive plan may be implemented.

18. Since any new crossing built within 10 miles of the existing Bay bridge would require modification of the State's statutes prohibiting such construction and coordination of the financing of any new structure with that of the existing bridge, the total revenue would not be materially affected by the location of a second crossing if it were within reasonable distance of the existing bridge.

19. Traffic distribution on both sides of the bay is of prime importance and should be worked out in cooperation with the authorities of the terminal communities involved.

20. The location of the recommended crossing will require that the present restricted Naval seaplane area be moved northward so that the crossing will clear the marked seaplane runways within the area and will require that the seadrome facilities of San Francisco Airport be made available for emergency use by Naval seaplanes.

IV. RECOMMENDATION

The Board having given due consideration to all the facts recommends that:

1. A six-lane combination open causeway-tube be constructed immediately with proper clearances from the vicinity of Army Street in San Francisco to the vicinity of 5th Street in Alameda with a four-lane extension under the Oakland Estuary to the proposed East Shore Freeway, and;
2. Plans be developed for an electric rapid-transit system for mass transportation carried across the bay in a centrally located subaqueous tube devoted solely to that type of traffic.

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PART B

DISCUSSION

I. THE PROBLEM.

1. The Directive. The mission given to the Board by House Resolution 529, 79th Congress, was to determine the need and feasibility from either the standpoint of national defense or the development of peacetime economy, or both, of constructing either a bridge from San Francisco to Bay Farm Island or a system of dams across San Francisco Bay as provided for in the so-called Reber Plan as a solution of the cross-bay traffic problem.

2. The Problem. The problem is one of relieving the congestion of passenger automobile traffic during peak hours on the existing San Francisco-Oakland Bay Bridge. This bridge provides six lanes (three in each direction) for passenger vehicles on its upper deck, and on its lower deck, three lanes for truck and bus traffic throughout most of its length in addition to double tracks for interurban trains.

II. PREPARATIONS FOR THE PUBLIC HEARINGS.

1. Organization. The Board held a series of ten meetings prior to the public hearings. The initial meeting was held June 4, 1946. At the third of these meetings, Lieutenant Commander Paul E. Seufer, CEC, USN, was made available to the Board by the Commander, Western Sea Frontier, and was appointed by the Board as recorder without vote.

2. Scope of the Study. In analyzing its mission, it was apparent to the Board that House Resolution 529 and the precept issued to the Board by the Secretaries of War and of the Navy were not consistent. The Board accordingly drafted its understanding of the scope of its mission as defined by both documents and requested confirmation of

this understanding from the Secretary of War and the Secretary of the Navy. This conception of the Board's mission, which was confirmed by the Secretary of War and the Acting Secretary of the Navy on July 16 and 18, 1946, respectively, was that the Board should:

a. Investigate all locations and types of crossings necessary to recommend that which it considered the best.

b. Limit its investigation to the need for additional crossing facilities and include only those economic advantages of added facilities (industrial sites, shipping berths and airport sites) created by the Reber Plan which would have a direct effect on traffic.

c. Consider the feasibility of such a crossing.

3. Previous Study. A resume of policies and studies since 1917 on the subject of a San Francisco Bay crossing was prepared and studied by the Board. This is included as Appendix No. 20. The following extracts are of particular interest:

a. War Department Policy, 1921.

* * *

"c. That a tunnel crossing the bay will be approved in any location, provided the highest part of the structure is placed at least 50 feet below mean lower low water and proper compensation is made for obstruction of cross section as affecting tidal flow.

"d. That a combined bridge and tunnel will be approved at a location south of the proposed Alameda Naval Base site, provided that the tunnel is so placed as to leave the tunnel along the San Francisco side unobstructed to a depth of 50 feet at mean lower low water for a width of 3,000 feet measured from the nearest point of

the pier line and provided that proper compensation is made for obstruction of cross section as affecting tidal flow.

* * *

"Favorable consideration be given to a plan conforming to these requirements and having the necessary financial backing and the support of the local authorities of the cities and counties affected."

b. Board of Engineers, Transbay Bridge, San Francisco, May 1927. This Board was authorized by the Board of Supervisors of the City and County of San Francisco on March 28, 1927. It was composed of three prominent engineers and worked in conjunction with the City Engineer. In its precept, it was ordered to make a study of, and report on, the three best locations for a transbay bridge and the proper clearances, loadings, and traffic provisions for the structure. In its conclusions, this Board recommended that no provisions be made for main-line railroad traffic on any bridge, due to the small amount of this main-line traffic in comparison with the local commuter traffic and because of the grade limitations and consequent increased cost which such a provision would impose on any structure. It suggested that main-line traffic be brought into San Francisco by means of a tube when such a step became economically feasible. New York City was cited as an example. This Board considered bridge type of crossings only and recommended three possible locations.

(1) Rincon Hill to Alameda Mole;

(2) Potrero Point to a point south of the inner end of Alameda Mole and west of Pacific Avenue, Alameda, with approaches to Alameda Mole and to the foot of Pacific Avenue, Alameda;

(3) Telegraph Hill to Yerba Buena Island to the Key Mole.

It recommended location (1) as the best solution. In arriving at its conclusions, the Board indicated that its recommendations must be considered in the light of the fact that, with the exceptions of two borings, there was no information available regarding bay foundation conditions.

c. Hoover-Young Report, 1930. In August 1930, a report on San Francisco Bay crossings was submitted by the Hoover-Young San Francisco Bay Bridge Commission. This report resulted in approval of the plans for the present bay bridge. The commission reported on five locations, No. 5 of which contemplated a bridge springing from Hunter Point and landing on approximately the southwest corner of Alameda. The five locations studied were largely based on a crossing which would satisfy the needs of interurban railway commuter travel and general freight and passenger vehicular travel. This board recommended that: "Location #4 from the Rincon Hill District in San Francisco via Yerba Buena Island to Oakland over the Key Route Mole be adopted, the crossing to have a main channel span 1,700 feet long with 220 feet vertical clearances above low water and approximately 1,600 feet horizontal clearances between pier fenders."

d. Joint Army-Navy Board, 1941. A Joint Army-Navy Board was appointed in July 1941 to "investigate and report upon the need and feasibility, from the standpoint of the national defense, of constructing a bridge between Hunter Point and Bay Farm Island." The Board concluded that "from the standpoint of the national defense, there is no present or immediately prospective need for a bridge across San Francisco Bay between Hunter Point and Bay Farm Island" and recommended against such

construction. It also concluded that it was feasible to construct either a high- or low-level bridge between the termini specified and recommended that a high-level type be constructed if such a crossing were built.

4. Data on the Reber Plan. Investigation of this plan indic ated that it appeared to exist only as an idea of its author, Mr. John Reber, and had been publicized to a limited extent in magazine and newspaper articles. Little factual data were available on the plan. In order to obtain a clear understanding of the plan, under date of June 25, 1946, the Board addressed a letter to Mr. Reber which read in part as follows:

"We assume that the Reber Plan is officially the scheme described on pages 103 to 105 of the March 1942 edition of the Western Construction News.

"The Board requests that you confirm this assumption, also that you provide us by letter with an up-to-date revision of the cost estimate indicated on page 104 of the article, including the unit costs on which the figures are based, your plan for handling traffic, the location of the ten tubes and the general scheme for the approaches to them from the existing highway and railroad systems."

The article q uoted above, the letter to Mr. Reber, and his reply are included in Appendix No. 5. The reply added little to the article, so the Board was forced to accept the article as the best available information on the Reber Plan and directed all inquiries concerning the plan to this article.

5. Other Data Available.

a. The Board adopted a policy that no personal presentations would be accepted prior to the public hearings except that data would be solicited from the State of California and

comments on the proposed additional crossing would be requested in writing from the local military and naval commanders. These latter are included as Appendix No. 3 and are discussed elsewhere in this report.

b. Under date of October 30, 1945, the California State Toll Bridge Authority directed the Department of Public Works "to make a comprehensive engineering investigation and study of the need for an additional bridge across San Francisco Bay from the San Francisco side to the East Bay without limitation as to location, the study to include consideration of the financial requirements of such a bridge."

c. The Board met with Mr. C.H. Purcell, State Director of Public Works, in his office in Sacramento on June 26, 1946, to ascertain the State's progress with its study. The Board found the State willing to cooperate in every way possible but was informed that the State's studies would not be completed until about January 1, 1947. The State did, however, discuss with the Board the results of its traffic survey to date and made available to the Board plans for the sites under consideration and plans of existing and proposed freeways. The State indicated that, while its last detailed study of traffic was made at the time of the construction of the present bridge, the results of spot checks made in 1943 and in March 1946, considered in conjunction with traffic data on the present bridge and other known facts concerning the local traffic, confirmed the pattern of traffic sufficiently for the purpose of its present study. Furthermore, the State intended to confirm the traffic pattern definitely when detailed studies are

completed about January 1, 1947. The problem of providing a crossing facility for transcontinental main-line railroad traffic was also being considered by the State. However, the State officials pointed out that such a provision would complicate financing of any new crossing due to the added cost and the inherent complications for revenue bond financing; by law, the California Toll Bridge Authority can only finance structures through the medium of revenue bonds. All presently available boring data were offered to the Board by the State and the Board was advised that, when the proposed locations became better defined, additional borings would be taken and the results of these would be made available to the Board.

d. As the Reber Plan involves the construction of dams analogous to salt-water barriers across San Francisco Bay, and because a great deal of prior investigation had been made by the State on a salt-water barrier in the upper regions of San Francisco Bay, a subcommittee of the Board met in Sacramento on July 9, 1946, with Mr. Hyatt, the Chief of the Division of Water Resources for the State of California. Mr. Hyatt indicated that, in so far as the Division of Water Resources was concerned, a salt-water barrier was not necessary. The general question of the salt-water barrier and the increased costs of levee maintenance and drainage in the Delta area were discussed. Copies of the various bulletins of the Division of Water Resources bearing on a salt-water barrier were presented to the Board and are included as Appendix No, 20. Mr. Hyatt stated that the conclusions of the Division of Water Resources with respect to a salt-water barrier are given in Division of Water Resources Bulletin No. 28 and that the State contemplated no further studies in the near future.

e. Due to the changes in natural characteristics which would result from a construction of any dams or barriers in San Francisco Bay and the consequent probable effect on the public health, a subcommittee of the Board met with Dr. Wilton L. Halverson, the State Director of Public Health, at his office in San Francisco on July 16, 1946. Dr. Halverson pointed out that the disposal of sewage and industrial wastes into tidal estuaries was much more satisfactory than similar disposal into fresh-water lakes and expressed fear that, if fresh-water lakes were to be created, nuisance conditions would shortly obtain around the various out-falls into these lakes. He pointed out that, under a recent resolution of the State Board of Health, the State Department of Public Health is at present undertaking a vigorous campaign to eliminate the sewage pollution of the waters of the State. In its campaign, the State has established certain standards regarding municipal and industrial waste treatment for the San Francisco Bay area. These have been based on the present character of the bay with great reliance for pollution control based on the volume of the tidal prism. The need for more intricate and complex treatment plants, if waste disposition were to be made into fresh-water lakes, was pointed out. In addition, this economic burden of waste treatment could possibly become so prohibitive and cause such an increase in operating costs as to force the relocation of existing industries.

6. Board Reconnaissances. Reconnaissances were made from the air, land, and water of the crossings recommended by the 1941 Board from Hunter Point to Bay Farm Island, of the crossings being currently studied by the California State Department of Public Works, and of the

dams outlined in the Reber Plan. The water reconnaissance of the latter included traveling over the center lines of the proposed north and south dams and of the proposed east channel.

7. Funds. After reviewing the information available and considering the data that would probably develop at the public hearings, the Board estimated that $23,000 would be necessary to permit it to make essential studies and conduct the public hearings properly. This sum was made available to the District Engineer from Appropriation 21 x 3000 Maintenance and Improvement of Existing River and Harbor Works.

8. Board Studies. The Board's studies of the Reber Plan are included as Appendix No. 5. The studies cover such items as reduction in the tidal prism and the consequent effect on the bar off Golden Gate, the problems of silting, water supply calculations, and time lost due to lockage.

9. Organization of Public Hearings.

a. The State Chamber of Commerce was considered the organization best qualified to coordinate for the Board the presentations of interested parties at the public hearings. The Chamber agreed to assume this duty and assigned Messrs. Fred C. Tatton and Vinrace M. Moir to work with the Board. A notice of public hearing was issued June 12, 1946, announcing a public hearing to be held in San Francisco on August 12, 1946. A mailing list of interested parties was compiled totaling 2,332 addressees. An agenda was adopted and released to the press on August 2, 1946.

b. The Board decided that during the hearings no questions from the floor would be entertained, but reserved to itself the privilege of questioning after each presentation. It also granted interested parties the opportunity of making additional presentations

to the Board in writing during the thirty days immediately following the close of the public hearings. A stenographic service was secured to record the hearings which are attached in four volumes as Appendix No. 14.

III. BRIEF OF THE PUBLIC HEARINGS.

1. Public hearings were conducted in Polk Hall in the Civic Auditorium of San Francisco, Monday, August 12, 1946, and continued for four days until all those desiring to make presentations had been heard. In the following summary of the hearings, the numbers in parentheses refer to pages in the transcript of the public hearings (Appendix No. 14).

2. Some twenty plans for crossings, including ten by the California State Department of Public Works, were presented. In general, the hearings developed the following:

a. A need for an additional crossing from the viewpoint of the peacetime economy;

b. Strong opposition to the Reber Plan;

c. A strong demand by the City and County of San Francisco for bringing main-line railroad trains into San Francisco, unsupported by a proved need;

d. In general, no opposition by the East Bay communities to the inclusion of provisions for main-line railroad trains, provided such inclusion could be shown to be economically justified.

3. The initial presentations were made by Senator William F. Knowland and Congressmen Richard J. Welch, Franck R. Havenner, and George P. Miller who emphasized the need for an additional crossing. The congressmen dwelt on the necessity for including provisions for main-line railroads on any crossing built. A brief summary of the plans offered and of the presentations of the various interested

groups follows in the order in which they were made.

4. Plans.

a. State of California Department of Public Works. This agency advanced ten plans for the crossing; seven of these were for high-level bridges based on Yerba Buena Island. The others contemplated a tube in the vicinity of the present bridge, a high-level bridge from Potrero Point to Alameda, and a low-level bridge from Candlestick Point to Bay Farm Island. It further reported upon its progress to date on the studies previously mentioned, furnished the Board with available data, stated its willingness to furnish additional data, and indicated that the existing bridge would be paid for by 1953 (26). The need for another crossing was also established (27, 28) and it was further stated that the location and type of this crossing would depend on the approach facilities provided by the terminal communities (28, 29). A description of freeway plans was given by the District Engineer of the State Division of Highways who also affirmed that the approaches for another crossing should be designed and constructed as an integral part of that crossing.

b. Taggart-Aston Plan. This plan was in two parts; a fresh-water barrier with locks and flood gates carrying high-level highway and low-level railway across the north bay and a low-level bridge across the south bay with a tube under the channel (51-55).

c. Reber Plan. This proposal is discussed in detail elsewhere (57, 68, 74-111, 133-139, 154).

d. Nishkian Plan. This plan was a modification of the southern portion of the Reber proposal. It provided a 2,000-foot solid causeway with channel tubes carrying 24 highway lanes and 4 rail tracks (166-175).

e. Tomasini Plan. This project provided a tube about six miles long (31,260 feet) to carry two rail tracks and four to eight highway lanes from 6th and Howard streets to the Oakland Mole (180).

f. Dennison Plan. This plan was a variation of the Reber Plan. It provided a 1,200 foot solid causeway to Yerba Buena Island under the present bridge with draw spans over eight locks, a wye-tunnel through the island, one leg leading to a causeway under the present bridge to the Key Mole, and the other to a causeway from Treasure Island to Raccoon Strait via Angel Island. Ship locks were provided in the straits, and highway and railroad facilities were provided on all causeways (200-212).

g. Little Plan. This project was a long term plan of bay crossings which provided that three additional crossings would ultimately be necessary; one at Market Street, either a bridge or tube for highway and interurban rails; a bridge or causeway and tube at 16th Street; and a Van Ness Avenue-Berkeley bridge or causeway and tube with one branch going to Berkeley and the other to Sausalito (219,344).

h. Mohr Plan. This plan provided tubes with electrified railroad facilities for main-line trains and for automotive traffic (561).

i. Bolander Plan. This provided for high-speed monorail interurban facilities to be supported on brackets from the present bridge (686).

5. State of California Agencies.

a. Division of Water Resources. Analyzed the Reber Plan (389 to 392) and concluded that, by construction of the Reber Plan -

(1) Practically none of the water supply benefits would be realized.

(2) Navigation would be impeded.

(3) Channel maintenance would be increased.

(4) The Delta levee system would be destroyed.

(5) The fishing industry would be injured, and

(6) Extensive expansion of sewage-treatment works would be required.

The only advantage the Division foresaw was a benefit to water-front structures above the barriers due to reduced destruction by marine borers.

b. Department of Public Health. Estimated the additional capital cost of sewage-disposal works at $100,000,000 if the Reber Plan were constructed (223).

c. State Lands Commission. Expressed its concern over the Reber Plan or any solid structure which would prevent free access of shipping, thereby eliminating industrial leases (232) and reducing the revenue from tidelands.

d. Division of Fish and Game. This agency felt that the Reber Plan or any plan utilizing dams would endanger migratory and resident fish. Sudden changes from salt to fresh water at fish ladders might kill fish and currents in summer might be too light to head fish to the ladders or allow seaward migration of fingerlings. In addition, the temperature in the lakes would increase and trout and salmon would be killed enroute to spawning grounds.

e. Reclamation Board. Opposed the Reber Plan because of its effect on Delta lands (224). Sacramento-San Joaquin Delta levees are constructed of peat on peat foundations and require constant up-building to offset settlement. They are damaged now by occasional

high water which reaches elevations that the Reber Plan would make permanent (227-229). Seepage would increase and materially increase the cost of drainage pumping. Further, the Shasta Dam has ended the need for a salt-water barrier (225).

f. Joint Committee on Water Problems. This legislative committee supported the reports of Division of Water Resources and of the Reclamation Board (239).

g. Board of State Harbor Commissioners. Favored a southerly location (515-516), opposed solid-fill moles and inclined portions of masonry tube beyond the pierhead line, indicated the need for a 2,000-foot channel (519) beyond the San Francisco pierhead line and held that the Board of State Harbor Commissioners, as trustee for the shipping interests, should be reimbursed for damage to water-front property and activities caused by any new construction (520-521).

h. Golden Gate Bridge and Highway District. Supported the plan for another San Francisco Bay crossing and indicated that it should provide for railroad facilities.

6. Counties.

a. City and County of San Francisco (Including the Chamber of Commerce and Other Civic Groups).

(1) Need. This group held that the need for an additional highway crossing was obvious. It concentrated its presentation on a demand that provisions for bringing main-line railroad trains into San Francisco be included in plans for an additional crossing. However, although the demand was emphatic, no factual data were presented to establish the need for including railroad facilities. The plea was

principally for passenger facilities. The Chamber of Commerce stated that there was no need for railroad freight facilities, although additional provisions should be made for truck traffic.

(2) Location. The group favored a location south of the present bridge and north of Hunter Point. It preferred a terminus in the vicinity of Army Street in order to fit into the City's Master Plan. This group did not specify or recommend any type of crossing, but left that decision to the Board. Some support was given by this group to an earth-filled causeway, but this was far out-weighed by the opposition to any such plan. Upon the introduction of subsequent testimony indicating that substantial areas of land would have to be made available for terminal facilities if the railroads were brought into San Francisco, the Board requested information as to the City's plans in this regard, and was furnished by one of the City's supervisors with two possible areas for a passenger terminal, but none for freight.

(3) Criteria Recommended. The City Engineer listed criteria for the location of an additional crossing as follows (292,293):

(a) It should not hinder water-front operations.

(b) It should serve present and future traffic.

(c) It should be far enough from the present bridge to permit proper terminal distribution of the traffic and to prevent any common harm to both crossings in the event of a catastrophe.

(d) It should permit convenient locations for rapid transit systems and main-line railroad trains.

He made the point that State location No. 10 would best meet these criteria and that 30 per cent of the present traffic on the Bay Bridge

could utilize such a new crossing with no increase in distance traveled. Furthermore, that all of the present traffic could use this crossing by traveling an average distance about two miles greater than by the present route.

b. Alameda County (Cities, Chambers of Commerce and Other Civic Groups).

(1) Need. The Alameda group presented figures to indicate that the present bridge would be overtaxed before another could be completed (350).

(2) Location and Type. The group felt that the location and type of structure should be determined by a comprehensive engineering study for which the California Toll Bridge Authority is best qualified (346). The group stated that it was unalterably opposed to the Reber Plan or any modification of it that would interfere with present, or hinder proposed port facilities.

(3) Criteria Recommended.

(a) The presentation of the consulting engineer for the County's Committee for a Second Bay Crossing is attached as Appendix No. 17. It held that:

(1) Alameda must be served (352) and future harbor plans at San Leandro considered.

(2) A crossing north of the Oakland Estuary must be a high-level bridge.

(3) Based upon the experience of other communities, railway facilities are not necessary on the proposed crossing (352).

(4) Tubes should not be considered because of high construction and operation costs (358).

(b) The report also concluded that the Reber estimates were faulty as to quantities, unit costs and conception of work required (363, 365, 366) and that the plan would destroy port values, fishing, salt and chemical industries; would increase cost of sewage disposal and waste fresh water (353); and that the Nishkian Plan estimates were inadequate and that the plan would create a hazardous tidal race through the 2,000-foot channel it proposed.

(c) The Alameda County Water District presented a minority report favoring the Reber Plan (377) claiming that it would prevent intrusion of salt water into its underground supply.

c. Contra Costa County (Cities, Chambers of Commerce and Other Civic Groups).

(1) The Contra Costa County group did not comment on the need for an additional crossing nor on its proper location. It devoted its presentation to strong objection to the Reber Plan, particularly that part which converted San Pablo Bay to a fresh-water lake and created a channel through Richmond (395-401). They pointed out that it would interfere with industrial harbor plans for north Richmond (396) and delay vessels in reaching Richmond Harbor and the upper bay ports (397). They pointed out that the fresh water, being warmer, would increase the cooling costs of many industries (398) and that sewage disposal would be more expensive, not only for industrial wastes but domestic disposal as well (398, 400). Brine and chemical industries and fishing, both commercial and sport, would be destroyed (399-400).

(2) The report of the consulting engineer of the group is attached as A ppendix No. 18. In addition to the above objections to the Reber Plan, it held that the water could not be held high

(d) The reports also concluded that the Dover authorities were faulty on the grounds, that costs and underpriced of less regulated (304, 305, 306) and that the plan would discover port volume, traffic, and closedown industries would increase costs of average disposal and water fresh water (307); and that the Middle Plan options were inadequate and that the plan would create a bottleneck (308) pipe through the 2,000-foot channel it proposed.

(e) The Alcoda Clarke Water District presented a report for Dover Harbour, the Water Plan (309) criticized, that it would increase variance of rate water into undrinkable supply.

(f) Dover Town Council, Chamber of Commerce and other civic groups.

(g) The Central Water Board did not consent to the plan for additional storage on the Dover Lowlands. It favored the proposals to change objections to the Lower Plan, particularly that part which concerned the Ports Bay as a fresh-water lake and created a channel through Ramsgate (310-311). They pointed out that it would interfere with a commercial harbor plan for Ramsgate Harbour (312) and delay work in creating Ramsgate Harbor and the upper bay ports (313). They pointed out that the Ramsgate Harbor plans of Kent County Council, would increase the municipal costs of Kent Waterworks (314) and that storage objects would be only a temporary, and only for industrial water and drawing channel as well (315, 316). Water and channel improvement and fishing, with temperature and salinity, would be destroyed (317-320).

(h) The reports of the consulting engineers of the group is attached as a part of the 1954 Report. In addition to the above objections to the Lower Plan, it noted that the water could not be held high

enough to do any good without destroying the Delta (630), there would be a fresh water shortage of 3,000,000 acre-feet in dry years (642), and jetties and dredging would be needed to maintain the channel in the San Francisco Bay Bar (649). It called attention to the indirect costs of the Reber Plan as follows (654, 656).

Delta lands destroyed	$150,000,000	to	$200,000,000
Cyclic storage of fresh water	100,000,000	"	200,000,000
Sewage disposal	25,000,000	"	50,000,000
Industries destroyed	20,000,000		
Destruction at Richmond	10,000,000	"	25,000,000
Mosquito control	1,000,000	"	5,000,000
Jetties at the Golden Gate	25,000,000	"	75,000,000
TOTAL	$331,000,000	"	$575,000,000

(3) It was also stated that the Nishkian Plan would produce excessive tidal velocities in its channel and would build shoals in front of the existing San Francisco docks.

d. North County Groups. This group comprised San Joaquin, Sacramento, Yolo, Solano, Napa, Sonoma and Marin counties. These counties also concentrated their presentations on opposition to the Reber Plan. San Joaquin and Solano counties in the Delta area objected to the Reber Plan because it would waterlog their lands, make levee reconstruction and maintenance prohibitively expensive and increase pumping costs for the disposal of sewage and seepage from the low Delta lands of the central valley, since large areas in the Delta are below mean sea level (409-427, 433-434, 457-464). A large portion of the levees in this area are built of peat on peat foundations, the latter

have small bearing capacity and the levees cannot be raised to accommodate the higher stages the Reber Plan contemplates (425). The group was also apprehensive that the fresh-water lake created would stagnate with sewage (464), breed disease-carrying mosquitoes (457), and generally menace public health.

(1) Contra Costa County (398) and Solano County (455) objected to the effect of the Reber Plan on navigation because of loss of time in lockage and the silting of existing channels (456) it would cause. They also pointed out the vulnerability of the locks.

(2) Sacramento, Napa, Sonoma, and Marin counties indicated interest in the problem, but expressed no opinion or desires one way or the other. Yolo County was not represented.

e. Southern Group of Counties. San Mateo and Santa Clara counties comprised this group.

(1) San Mateo County did not make a presentation except to state that the Chamber of Commerce had taken a definite stand in favor of another crossing (474).

(2) Santa Clara County was also neutral except that it requested that approval not be given to the Reber Plan until it was shown that existing sewage and flood water problems would not be aggravated.

7. United States Government Agencies.

a. Army and Navy.

(1) The opinions of the local senior Army and Navy commanders on the need for an additional crossing from the viewpoint of the national defense and on the Reber Plan were canvassed by means

of a letter addressed to them by the Board. They were further requested to comment on the effect which a Yerba Buena group of crossings, the crossings recommended by the 1941 Board, and the Reber Plan would have on the national defense. Their replies may be found in Appendix No. 3.

(2) The consensus was that, although another crossing is not necessary from the viewpoint of the national defense, none of the local Army and Navy commanders objected to an additional crossing reasonably located with proper clearances. Objections were made against the Reber Plan which they felt would affect national defense adversely, would jeopardize the harbor because of vulnerability of the locks, would interfere with port facilities, eliminate the present fleet anchorage and cause an undesirable concentration of forces in the small salt water area remaining (426-505). The local Navy commanders further indicated that the Naval bases proposed in the Reber Plan are not necessary and their development costs would be large.

b. United States Fish and Wildlife Service. The service analyzed the effect of freshening large parts of the Bay, pointing out that salmon, striped bass and shad would suffer since they require both salt and fresh water in their life cycles and that shrimp would be exterminated (479-484). It opposed the Reber Plan.

c. United States Bureau of Reclamation. The Bureau denied some of Mr. Reber's claims, particularly with regard to the saving of $10,000,000 on the Delta cross-channel, the need for which has not been determined and felt that there might be a net loss rather than conservation of water resulting from the construction of the plan.

of a letter addressed to them by the Board. They were further requested to comment on the effect which a Korea Naval Group or crossing, the crossing recommended by the 1947 Board, and the Navy Plan would have on the military situation. Their replies may be found in Appendix Two.

(2) The conference was then, although which was necessary from the standpoint of the national defense, none of the local Army and Navy commanders objected to an additional crossing reasonably located with respect to Chuncheon. Objections were made against the Navy Plan which they felt would prove a national calamity, adversely, would jeopardize the mission because of vulnerability of the locks, would interfere with port facilities, disturb the fishing industry and cause an unbearable concentration of troops in the small area which would remain (420-424). The local Army commanders further indicated that the Navy at bases proposed in the Navy Plan are not necessary and the port development costs would be large.

g. Lower Naktong Dam and Hydro Station. The Navy Plan envisaged the effective irrigation of large parts of the Dry, providing our that salmon, striped bass and shad would enter those waters during both, bass and crappie would be there after spawning and the lake shrimp would be exterminated (424-426). It appears that the Navy Plan.

h. United States Bureau of Reclamation. The Bureau decided some of the dam sites during, particularly with regard to the storage of 210,000,000 of the Naktong-Nakdong, the need for water has not been established and that what there might be a more logical conservation of water resulting from the construction of the plan.

8. Transportation and Allied Agencies.

a. Water-borne Transportation. The shipping group objected to the Reber Plan because of the expense, delay, and hazard caused by the lockage necessary to pass through the dam (533-541,661). They expressed fear that increased port expenses would remove parity with competitive East Coast and Gulf Ports (534) and stated that delay of purse seiners at locks would jeopardize perishable cargo (661).

b. California State Automobile Association. Confirmed the need for another crossing (35), approved the study under way by the State (45), requested that origin and destination studies be fully considered and urged that the cost of non-highway facilities not be imposed on the motoring public (46).

c. The Greyhound Bus Company. Indicated that any new crossing should include four lanes for bus and truck traffic. The company stated that, if the new crossing is not near the existing bridge, it would use both in order to operate over the most direct routes (617).

d. Truck Owners' Association. Recommended a new crossing in the general area of the present bridge without rail facilities unless the railroad companies pay their share (447). They pointed out that rail revenues on the existing bridge are 8 per cent, although rail facilities cost 23 per cent of the total cost of the bridge (445,446). Survey by the Draymen's Association of Alameda showed that 95 per cent of its transbay business is between the central districts (450).

e. Key System. Desired four tracks instead of two to handle future suburban trains and travelers and a location near the existing bridge (615).

f. Yacht Clubs. Owners of small craft were not in favor of the fresh-water lakes. The San Francisco Yacht Club opposed the Reber Plan or any other plan that would interfere with free use of the bay (618).

g. Airlines. Five airlines urged the selection of a crossing serving the entire bay area and giving consideration to the importance of access to airfields (546).

h. Shipyards. Moore Dry Dock stated that the type and location should be left to engineers and opposed the Reber Plan as unwise and shortsighted.

i. Railroads. Of the three railroads serving San Francisco, only two made presentations.

(1) The Southern Pacific Company described its freight facilities over its low-level route via Dumbarton to the Bay Shore Yards. It indicated that a new crossing would not improve service even if terminal yards were available for expansion in either Oakland or San Francisco (528). It pointed out that a passenger terminal in San Francisco would require from 40 to 50 acres for the station and 25 acres for a coachyard (530). It stated that the fixed and operating charges for freight or passenger service should not be increased over the present scale (531).

(2) The Western Pacific expressed no interest in using a new crossing (522). It indicated that it has ample facilities which would have to be abandoned at a cost of $1,000,000 plus right of way (525), and that the present ferry operations are cheaper than they would be by rail.

E. Yerba Buena. Because of special trails were not in favor of the Treasure Island. The San Francisco Parks Commission opposed the Bahar Plan on any other plan that would interfere with free use of the bay (XXXV).

F. Airport. This situation shows the solution of a problem involving the entire bay area and giving consideration to the importance of access to airfields (XXXV).

G. Shipyards. Above Bay Bridge that the type and location should be left to engineers and approved the Bahar Plan as sketchy and abbreviated.

H. Recreation. Of the three recreation surveys San Francisco only two made recommendations.

(1) The Hunters Point Company operated the Treasure Facilities near the Ferry Building via Embarcadero to the Bay Bridge Island. It indicated that a new recreation center will be more attractive even if nautical yards were available for operation in either Oakland or San Francisco (XXXV). It recommended that a permanent terminal at San Francisco would require from 20 to 30 years for the structure and 20 years for a development (XXXV). It noted that the Board and operating company for Treasure Island or permanent service should not be interrupted during the present work (XXXV).

(2) The Western Pacific experienced no difficulty in having a new recreation (XXXV). It indicated that a new single facilities which would have to be abandoned at a cost of $1,000,000 plus risk of any (XXXV) and that the present Ferry operations are adequate than they would be by rail.

(3) The Atchison, Topeka and Santa Fe Railway did not make a presentation but indicated intention of filing one later (532).

9. Industrial and Agricultural Interests. The representative of some industrial interests recommended a crossing of conventional type and stated that the Reber Plan would (562-564):

a. Eliminate 85 per cent of the tidal prism and thereby shoal the Golden Gate and injure channels (Potato Patch Shoal is a reservoir of sand ready to shoal Golden Gate if tidal prism is diminished) (580). The tidal prism should not be reduced more than 10 per cent by any crossing (575,576). The San Francisco bar is of marine, not inland, origin and is in equilibrium between ocean forces and tidal currents. The Reber Plan would upset this equilibrium, raise the bar and convert the bay into a lagoon unless jetties five miles long were built (570-574).

b. Waste fresh water by lockage and evaporation with no net saving through storage. Since lockage losses would total 2,562,000 acre-feet per year (595), the South Bay would never become a fresh-water body.

c. Ruin the Delta by inundation. The lake level would be 8.0 above datum, destroying 300,000 acres of Delta farms (604).

d. Handicap shipping with expenses and delay. The annual maintenance of Redwood City, Stockton and Sacramento Harbor channels would be $300,000 to $500,000 because deepening by the Reber Plan would only be temporary (581). Daily lockage would average two hours per vessel each way (606), resulting in rehandling at San Francisco piers at extra cost, shipping through locks at higher rate, or loss of business to other carriers (610).

e. Conflict with national defense by enclosing bases behind vulnerable locks and concentrating anchorages in a smaller target area.

f. The small channel opening for the tidal flow provided by the Nishkian Plan would result in a virtual mill race which would be entirely impractical from a navigation standpoint. Further, the outgoing tide would scour Berkeley Flats and the incoming tide deposit the mud in the existing channels and water front of South San Francisco Bay (578).

10. Labor Groups. Three labor groups made a presentation. The San Francisco Labor Council urged that another crossing include rail facilities, contending that lack of these facilities would mean unemployment due to loss of industries to other localities (268). The Building Trades Council also asked for rail facilities on the crossing (269). The International Fishermen and Allied Workers Union expressed fear that the Reber Plan would destroy their jobs in the sardine industry (660).

11. Other Interests.

a. The Northern California Fisheries Association stated that their business would be destroyed (658), if the Reber Plan were adopted.

b. The Associated Sportsmen of California said the Reber Plan would be disastrous for fish and wild life, was not practical, and that the cost was underestimated.

c. Farm Paper. The editor of a farm paper commented favorably on the Reber Plan, and stated that it would break many bottlenecks for farmers. He urged a broader impartial study.

IV. PRESENTATIONS SUBSEQUENT TO THE PUBLIC HEARINGS

1. Plans. The Board received additional presentations in writing until September 15, 1946 (30 days after the close of the public hearings). These included additional plans, comments for and against the Reber Plan and the factual data concerning railroad operations which were requested by the Board from the railroads. Congressmen Welch and Havenner also submitted supplemental statements re-emphasizing the desire of their constituents for a crossing which would include railroad facilities. The plans received were, briefly, as follows:

a. THE BONNER PLAN. Presented by Mr. F. E. Bonner, San Francisco; contemplated the construction of a causeway and tube connecting 16th Street, San Francisco, and Main Street, Alameda, and with one centrally located channel, 6,000 feet wide.

b. THE SHAFFER PLAN. Presented by Mr. C. F. Shaffer, San Francisco; proposed a floating bridge and tube from Berry Street and the Embarcadero, San Francisco, to Alameda. It contemplated an elevated crossing over the Embarcadero, a tube which would provide a channel 1,000 feet wide, a 7,200-foot floating section which would be anchored in the bay, and 6,000 feet of trestle.

c. THE RIXFORD PLAN. Presented by Mr. Loring P. Rixford, San Francisco; contemplated a combination mole and tube, the San Francisco end of the mole being at the foot of Townsend Street, with a 6,690-foot tube section in the center of the bay, and a mole on the east shore landing in the proximity of the present Alameda Mole. Crossing of the Oakland Estuary would be by an additional tube.

d. THE WALSH PLAN. Submitted by James J. Walsh, San Francisco; proposed a bridge from the San Francisco shore just north of Hunter Point to a point on the pierhead line in the East Bay where the bridge would be served by two causeways, one causeway proceeding in a northeasterly direction toward Main Street, Alameda, with a tube crossing under the Oakland Estuary, and another causeway going east to Bay Farm Island, and integrated into the existing road system by means of additional sand fills around the western perimeter of the island.

e. THE DRAKE PLAN. Submitted by Mr. Fred H. Drake, San Carlos; proposed the installation of a solid fill causeway with an elevated viaduct across the lower bay from Candlestick Point to a point south of Bay Farm Island, with a connection to Bay Farm Island.

f. THE PAGANO PLAN. Submitted by Mr. Andrew J. Pagano, Oakland; proposed the construction of a high-level bridge from a point at approximately 20th Street in San Francisco, to the Western Pacific Mole, with ramps to the Alameda Mole on the east shore.

2. Suggestions. A suggestion submitted by Mr. R. S. Chew advanced the thought that, since the present problem is essentially an automotive commuting problem, an efficient rapid-transit system that would discourage use of the passenger automobile as a commuting vehicle would not only relieve the present bridge congestion, but also the traffic problem within the City of San Francisco itself. He advocated building a low-cost structure well south of the present bridge for ordinary vehicular traffic and expending the difference between its cost and the expected cost of a bridge at a northerly location on the development of an adequate rapid-transit system.

3. Railroad Presentations. The Santa Fe Railway Company, which did not make a presentation at the public hearings, the Southern Pacific Lines and the Western Pacific Railroad Company directed letters to the Board outlining the operating problems that would have to be overcome were a railroad bridge constructed and a union terminal established in San Francisco. None of the railroads would commit themselves as to the estimated costs of bringing the railroads into San Francisco because of lack of adequate engineering data and lack of personnel and money necessary to undertake the studies required before a realistic estimate could be made.

V. CONSIDERATION OF THE MEANS OF SOLVING THE TRANSBAY TRANSPORTATION PROBLEM WITHOUT MAJOR CONSTRUCTION.

1. In its studies, the Board gave consideration to methods or means which might solve the transbay transportation problem without any major construction. Among the factors tending to solve this problem would be:

a. Increased use of mass transportation.

b. Re-establishment of the ferries.

c. Increasing the capacity of the present bridge.

2. A discussion of these various factors follows below:

a. Increased Use of Mass Transportation.

(1) The question of increased use of mass transportation as a solution to the transbay transportation problem was investigated. There has been a definite trend from interurban trains to private automobiles. Prior to the construction of the present bridge, it was estimated that about one-third of the persons traversing the Bay Bridge

would travel by automobiles and two-thirds by interurban train. Actually, however, there has been an unexpected and material diversion from interurban trains to private automobiles and buses as indicated in the traffic study (Appendix No. 9).

(2) Three transportation systems ran electric trains over the present bridge after it was opened for that type of traffic in 1939. The Southern Pacific lines started curtailing their operations in January 1941 and by July 1941 had substantially stopped operations of electric trains over the bridge. The Sacramento Northern ceased their operations in July 1941 and during that same month, the Key System curtailed operations on one of their lines, the "H" line.

(3) Of interest in this regard are the following past predictions as to type of traffic that would probably use the present bridge and the actual division of traffic that is using the bridge at present. It will be noticed that, except for the increased population and activities resulting from the war, the estimates of total passengers are quite accurate, although the volume by types was practically the reverse of predictions. These predictions were made in the reports of the 1926 Board of Engineers, the Hoover-Young Commission in 1929, the California Toll Bridge Authority (CTBA), and in a survey by a firm of traffic consultants for the California Toll Bridge Authority, Coverdale and Colpitts.

	1926 Board of Engineers		Hoover-Young 1929	C.T.B.A.		Coverdale & Colpitts		Actual	
Passengers	1940 - 1946		1940	1940 - 1946		1940 - 1946		1940 - 1946	
Thousands by Automobile	15,308	17,721	22,081	18,120	22,400	16,380	18,480	34,440	65,060
By Interurban Train	43,492	46,631	36,759	36,150	37,536	34,965	38,426	18,424	23,100
TOTAL	58,800	64,352	58,840	54,270	59,936	51,345	56,906	52,868	88,160

(4) In 1929, over 78 per cent of the transbay passengers used the combination train and ferry service. In 1946, neglecting Yerba Buena Island traffic, only 26 per cent of the passengers were actually using the interurban railway facilities. At present, the number of passengers using their private automobiles is restricted by the availability of new automobiles, the capacity of the automobiles, congestion on the bridge and lack of parking facilities. It is the opinion of the Board that the commuting public using the present bridge would not be induced to change its traveling habits until suitable anc completely integrated rapid-transit facilities are provided in the East Bay communities and San Francisco.

b. Re-establishment of Ferries.

(1) The question of re-establishing ferry service as a solution to the transbay transportation problem was investigated.

(2) Ferries are subject to regulations by the State of California's Public Utilities Commission (formerly the Railroad Commission). They operate under franchise granted by the Board of Supervisors, City and County of San Francisco. One of the statutory provisions for the protection of bondholders of the California Toll

Bridge Authority provides that, so long as any bonds are outstanding on the San Francisco-Oakland Bay Bridge, no other bridge, tunnel, ferry or other crossing shall be built or instituted within ten miles on either side of the present bridge. This means that a ferry franchise would require action of the State Legislature and it is doubtful if favorable action would be forthcoming. This is probably one of the reasons why the Public Utilities Commission (Railroad Commission) has received no applications for re-establishment of ferry service. Furthermore, other factors indicate that a ferry service would be financially unattractive.

(3) The State of California Department of Public Works "Report Covering Preliminary Studies for an Additional Bay Bridge," Table 6A, reveals that, in 1937, one year after the opening of the San Francisco-Oakland Bay Bridge, vehicular ferry traffic dropped to 40 per cent of its 1936 volume. Also, that, in 1938, vehicular ferry traffic advanced to 84 per cent of its 1936 volume. Investigation into the reason for the increase reveals that, during the latter year, ferry fares had been reduced to half that of the bridge, i.e., bridge toll for passenger cars 50 cents each way, ferry tolls 50 cents round trip. This indicates that the increase in volume was due entirely to the attraction afforded by the reduction in toll charge and that, all things being equal, motorists preferred to use the bridge.

(4) However, by reducing the tolls, the ferries had anticipated drawing a much larger volume of traffic from the bridge and, as this did not materialize, it appears they continued to operate at a loss. This is readily understandable when consideration is given to the fact that tolls had dropped progressively from $1.05 per car in

1925 to 30 cents (one way) in 1938. Faced with steadily decreasing income and steadily increasing operating costs, the ferries finally suspended service. As bridge tolls have been 25 cents for some time, it would appear from the foregoing that ferries would have to charge less than that figure to attract any appreciable volume of traffic.

(5) Much has been said relative to poor commuter service between Alameda and San Francisco. It has been stated that, not only did the bridge fail to improve this situation, but it caused suspension of ferry service. While this is true, interviews with the Public Utilities Commission (Railroad Commission) and the Southern Pacific Lines indicated that the small volume of traffic from Alameda was the prime factor in the suspension of service. The period 1920 to 1925 was one of universally rapid growth in automotive use throughout the United States and the situation between San Francisco and the East Bay kept pace with the general development. The growth in automotive use accounted for the increase in ferry routes and service. On September 3, 1926, service to Alameda was commenced. This reached a maximum in 1928 and then began shrinking according to a survey made in 1936 prior to the opening of the San Francisco-Oakland Bay Bridge. As an indication of the relatively small volume of ferry traffic from Alameda, a comparison is taken from a traffic survey for the week of May 15, 1936, conducted by Coverdale and Colpitts and contained in a "Report on Estimated Traffic and Earnings, San Francisco-Oakland Bay Bridge, dated July 1936."

	Oakland Ferry	Berkeley Ferry	Alameda Ferry
Vehicles	43,786	19,764	1,167
Per Cent	67.7	30.5	1.8
Passengers	103,213	44,803	2,957
Per Cent	68.3	29.7	2.0

It is interesting to note that none of Alameda's small number of vehicles are listed as commuter vehicles. All are listed as casuals and foreign.

(6) The peak of Alameda's vehicle ferry traffic was reached in 1928 when an average of 42,000 vehicles per week were carried. This figure kept dwindling until, in the week of May 15, 1936, only 1,167 vehicles, or less than 3 per cent of the peak year, were carried. From these figures and other available information, the conclusion was reached that for a number of years Alameda ferries had operated at a loss and had been considering suspension of service long before the opening of the bridge.

c. Increasing Capacity of the Present Bridge.

(1) The possibilities of increasing the capacity of the present bridge by suspending brackets on the sides to provide additional lanes, by reversing traffic in the off-center lane during rush hours, and by using the lower deck for passenger vehicles during peak hours were studied, but were not considered practical principally because of the design of the distribution structures on both ends of the bridge. In addition, the uniformity of the volume of traffic in both directions does not make it practical to reverse the traffic in the off-center lane during rush hours and mixing passenger-vehicle traffic with truck traffic on the lower deck is too dangerous to be acceptable.

(2) During peak hours, eight toll booths in place of the normal six are available to traffic traveling in the direction of major flow. Additional toll facilities would relieve congestion at the booths somewhat, and these are scheduled for construction by the State.

It is interesting to note that none of Minneola's small number of vehicles are figured in commuter volumes. All were listed as occasional or non-commuters.

(4) The peak of Minneola's vehicle ferry traffic and revenue in 1952 came on average of 42,000 vehicles per year over ferry. This figure kept climbing until, in the year of May 1, 1956, only 1,167 vehicles, or less than 3 per day of the ferry year, were carried. Free bridge figures and other available information, the commission was advised that for a number of years Minneola ferry was operated at a loss and had been sustained by operation of service long before the opening of the bridge.

Operating Cost of the Ferry Facility

(5) The possibility of improving the operation of the present bridge by temporary measures so as to relate to present traffic demand times, by removing tolls on the bridge, have charging peak hours, and by using the lower deck for westbound vehicles during peak hours was considered, but were not considered practical or economically because of the design of the structure which requires the lower deck of the bridge. In addition, the maintenance of the volume of traffic in both directions which would be required to operate the ferry in the off-peak hour during peak hours was felt to be inadvisable because with ferry service on the lower deck is temporarily to be inoperable.

(6) During peak hours, when both vehicles in place of the normal six are available to handle the traffic, the operation of ferry. Additional toll collectors would be required, at the bridge terminals and those are authorized for construction by the Commission.

(3) From a consideration of the discussion above, it may be seen that it is impossible to solve the problem of commuter traffic congestion without major construction. This is further borne out by a study of the volumes of future traffic. The Board accepted the mean of the population and traffic predictions of the terminal communities as the estimate on which future need should be based. Appendix No. 9 gives the Board's traffic study. Using these data and assuming that the passenger automobile capacity of a new crossing would be the same as that of the present bridge, an examination of Figure 3, A ppendix No. 9, reveals that the present crossing would again become congested, as given in the table below. Percentage of demand accepted by the new crossing was used in this table because the State Department of Public Works in Appendix 7 uses this criterion for the adequacy of bridges at various locations.

Percentage of Demand Accepted by New Crossing	Year Present Bridge Would Again Become Congested
11%	1953
25	1962
33.3	1970
37½	1980

Figure 3, Appendix No. 9, indicates that the capacity of the present bridge will be exceeded by the time any new crossing could be constructed, and further shows the relative futility of taking any stopgap measures other than a new crossing facility. It is also interesting to note that this table shows that:

(a) In 1954, the earliest date it is estimated that an additional bridge could be completed, the traffic demand would pass the point where a Hunter Point-Bay Farm Island crossing would provide any relief for the congestion on the present bridge.

(b) If the additional crossing were built at Army Street or Telegraph Hill, the present bridge would probably again become congested about 1962 as only 25 per cent of the traffic would be naturally attracted to these crossings.

(4) It should be noted that this percentage of demand, accepted by any crossing, does not take into consideration the traffic induced by another crossing which is covered elsewhere in this discussion, nor is any consideration given to the other factors which should govern the location of any new crossing.

(5) Also of interest is the trend in the movement of the centers of automobile vehicular traffic demand. The Hoover-Young Commission established the centers of vehicular traffic in 1929 as near the Civic Center in San Francisco and near Moss and Oakland avenues in Oakland. In the intervening 17 years, the Board has determined that the center of demand on the San Francisco side has moved to the vicinity of Market and 11th streets, about a q uarter of a mile to the south and slightly to the east of the Civic Center. During the same time, it has found the center of demand on the Oakland side has moved to the vicinity of 45th Street and Lawton Avenue, almost a mile to the north and a quarter of a mile west of Moss and Oakland avenues. If these trends continue in the same directions and at the same rates, the Board estimates that by 1980 the center of demand on the San Francisco side will be about in line with the axis of the present bridge but, on the east side of the Bay, it will be considerably to the north of the axis of the present bridge, reaching Ashby Avenue in Berkeley, in about 30 years.

(d) If the additional expenses were built as they
stand at Kingston Mill, the present Dundas main would again be-
come congested when just on every 25 per cent of the traffic would be
normally attracted to these crossings.

(e) It should be noted that this percentage of traffic
attracted by the crossings, does not take into consideration the traffic
diverted by another crossing and at an average elevation in this line-
ration, not in any functionality given to the other factors such
as time factor and location of any new crossing.

(f) Also of interest is the trend in the movement of the
amount of traffic at the Hamilton Bridge. The accompanying
diagram indicates the amount of traffic in 1920 as
compared with 1926 in the Transition and near Dundas was included
in the count. In the intervening 12 years, the value has
increased more than 40 per cent of 1920 or the first year alone was
used in the calculation of factors and line analysis. There is a marked
value in the rapid and diagonal in the case of the Twin Tunnels.
The increase is in the figures for amount of traffic on the
Dundas line has moved to the Hamilton on as a direct and lower
tunnel. The trend is the same for the Hamilton Bridge. It is also seen
that the amount of traffic. The same trends exist in the Twin
Tunnelling and in the Twin Bridge. The Dundas traffic is by long
the amount of traffic on the Twin Tunnelling also will be about 1/ also
with the main on the Hamilton Bridge and. In the case of the Twin
it will be noticed that in the month of the month of the Twin
Tunnelling, traffic was lower in December, in about 20 years.

(6) As there are no means of solving the transbay transportation problem without major construction, and the traffic estimates of the Board and other interested parties indicate that the present bridge will soon reach its designed capacity, a second crossing of San Francisco Bay between San Francisco and Alameda counties is now necessary.

VI. NEED FOR RAILROAD FACILITIES.

1. The City and County of San Francisco, supported by various civic, commercial and business organizations, strongly advocated that the second bay crossing include the provision of facilities to bring main-line railroad service into the City of San Francisco. It was generally felt that this type of service should serve passenger traffic.

2. The railroad companies did not feel that such service was warranted as it would greatly increase the cost of operation and, further, they were not interested in contributing toward any of the costs incident to the provision of such facilities on a second bay crossing. The armed services felt that there was no established need for such main-line railroad facilities from the standpoint of the national defense. While East Bay communities did not object to the extension of main-line railroad facilities into San Francisco, they did emphasize the fact that any such extension should be proved economically feasible.

3. The City and County of San Francisco did not present any factual data indicating a real economic need for main-line railroad connections to that city. It has been estimated that, even if main-line railroad connections were provided terminating in San Francisco, not more than one-third of the passenger traffic would find it desirable or necessary to continue on to San Francisco as a terminus. It has been

estimated that at least two-thirds of the through passenger traffic would disembark at Berkeley, 16th Street, Oakland, or the Oakland Mole and be transported by bus or other conveyance to the City of San Francisco, if that city be the terminus of the passenger. This is due to the fact that by means of existing bus and ferry service, it is probable that passengers would arrive at their ultimate destinations in San Francisco much sooner through these means than by that afforded by a transbay bridge crossing with subsequent taxicab service to the ultimate destination.

4. The Public Utilities Commission (Railroad Commission) of the State of California has had no official complaint or any official request to investigate the need and desirability of providing through main-line railroad service to San Francisco.

5. While it may be legally possible to force the railroad companies to bring main-line railroad service into San Francisco against their will, it is doubtful that this condition could be imposed upon the railroads without extensive litigation which would probably continue over a long period of years. Furthermore, it is highly probable that no success would result from such litigation unless it could be proved beyond a shadow of doubt that the furnishing of such service to the City of San Francisco were economically justifiable. No data whatever were submitted to the Board to indicate that the provision of transcontinental railroad service into the City of San Francisco was economically justifiable.

6. Main-line railroad traffic prefers a grade not exceeding one per cent, while highway traffic can successfully negotiate grades up to

5 per cent, although heavier truck traffic prefers that this maximum be established at 3 per cent. To introduce main-line railroad traffic onto any bay crossing requires that the structure must be made longer in order to provide for the maximum ruling grade for railroad trains. There are very few high-level bridges in the world which provide for main-line railroad traffic because of the large capital outlay required to meet this ruling grade consideration. Again, railroad locations have become established through the years and great sums of money have been expended for rights of way, terminal facilities, coach yards and marshalling yards. These existing railroad facilities very seldom parallel the needs of highway traffic and, consequently, the provision for both highway and railroad traffic on any crossing compromises the demands of both railroad and highway traffic. In the San Francisco Bay area the railroads have well-established terminal and allied facilities and the contiguous areas on both sides of the bay are highly developed. It is a physical impossibility to provide any one crossing which would tie into existing railroad facilities even without any consideration being given to highway traffic. Any structure located to serve highway traffic primarily would necessitate large expenditures from the railroads serving this area if they were to utilize this structure. In addition, the City of San Francisco is already congested, and providing adequate terminal and coach-yard facilities in this city alone for a union passenger terminal would be very expensive, not only in securing the necessary land, but also in the reduction of the City's potential ability to take care of future business, and also the reduction of the tax rolls.

7. The present State law vests the right to build toll crossings solely in the State Toll Bridge Authority and requires that this authority finance the construction of its toll crossings through the sale of revenue bonds. It then becomes necessary for the State Toll Bridge Authority to present an attractive proposition to the prospective investor. The provision of main-line railroad facilities on any crossing which materially increases the costs of such a crossing makes revenue bond financing extremely difficult, if not impossible.

8. In view of the factors cited above, the Board has concluded that it is impracticable, if not impossible, to provide a single acceptable type of crossing which will meet the necessities of, and the desires for, automotive vehicular and main-line railroad traffic.

VII DISCUSSION OF PRINCIPLES WHICH SHOULD GOVERN LOCATION.

1. Need: From the standpoint of the peacetime economy.
From the standpoint of the national defense.

The solution to the crossbay transportation problem has an important bearing upon the local economy both in peace and in war. The solution, therefore, should be that proposal which would provide for the greatest benefit to the entire bay area considered as an economic entity and which would give reasonable protection to the national interests.

2. Location.

a. The precept limits the Board's studies to consideration of the areas north of the vicinity of Candlestick Point on the west, and north of the vicinity of Bay Farm Island on the east.

b. Any additional bay crossing should be located so that it would adequately and economically provide a substantial portion of the automotive commuter traffic with a fast route, not necessarily the one

most direct, between the centers of demand on either side of the bay, or an acceptable means of mass transportation.

c. The location selected should:

(1) Serve present pattern of traffic reasonably well, and provide for probable future traffic with due consideration for probable changes in points of origin and destination.

(2) Discharge vehicular traffic into areas providing, now and in the future, easy, rapid dispersion of traffic between the crossing and the central business district in San Francisco, and the center of demand on the east side of the bay over existing or definitely planned arterials.

(3) Provide minimum interference with national defense.

(4) Provide minimum interference with navigation.

d. The second criterion above establishes the requirement that a proposed crossing should be so located as to permit ready dispersion of traffic over existing and planned traffic arteries. This criterion is of such importance that some brief discussion is desirable. Authorities have estimated that vehicular traffic emptying into a traffic-controlled street would reduce the lane capacity of a bridge or tunnel by 50 to 65 per cent.

e. The approaches are the valves which control the capacity of any crossing. Generous approaches and connections to main arteries are equally as important as the crossing itself. Without adequate means to get to and from any new transbay crossing, such a crossing could not

be economically justified. If the approaches to a crossing are found inadequate after even a short period, the cost of elaborating on such approaches may reach 100 to 200 per cent of the cost of the crossing itself. This is well illustrated in the fundamental inadequacy of the approaches to the Brooklyn and Queensborough bridges in New York City. These crossings are still useful, but would require such tremendous expenditures for adequate entrance and exit facilities that the City of New York in 1940, as a less expensive alternative, decided to spend $68,000,000 for the Queensborough Midtown Tunnel and is now spending an additional $80,000,000 for the Battery Tunnel. In connection with these two old bridges, the original design did not contemplate the tremendous increase in traffic which has obtained throughout the years since these bridges were first opened to traffic. It proves that a great deal of foresight in approach design is necessary if the entire capacity of a crossing is to be utilized effectively.

3. Type.

a. The principal considerations affecting the type of crossing selected are:

(1) Foundation conditions.

(2) Minimum interference with navigation.

(3) Minimum interference with national defense.

(4) Possible damage to present agricultural and industrial activities and natural resources.

(5) Minimum damage to, or interference with, existing facilities disposing sewage and industrial wastes.

(6) Cost of construction.

(7) Annual cost of operation.

(8) Feasibility of construction.

b. There are various types of crossings which would meet the foregoing criteria in varying degrees. These consist of:

(1) High-level bridges.

(2) Continuous low-level bridges with draw span or vertical lift span.

(3) Continuous tubes.

(4) Combinations of either a mole, an open causeway, or a bridge with a tube.

c. All types of crossings are feasible to construct. Some are inherently more difficult to construct than others. It is imperative that any crossing selected be capable of withstanding earthquake shocks. It is also desirable that the crossing afford the greatest possible resistance to all kinds of bombing attack. It is, of course, possible to construct a continuous tube which will be capable of resisting earthquake shocks, and it is also possible to construct a high-level bridge capable of resisting earthquake shocks, provided it is securely anchored to afford great resistance to lateral forces. Generally speaking, it would appear that a low-level crossing combining the mole and open causeway type of construction with a tube can be designed more readily to resist earthquake forces than any other type of crossing. The degree of resistance to earthquake shocks afforded by any design would be reflected to a certain extent in the initial cost of the structure. No crossing of the bay under consideration traverses known geological faults.

d. The following, while not criteria, are principal factors which the Board feels should be given special consideration:

(1) The crossing should be an appropriate component of an overall general plan providing for cross-bay transportation over an extended period of years.

(2) The City of San Francisco expressed a strong desire at the public hearings for a crossing south of the existing bridge. Its plea was based on the belief that such a location would stimulate the commercial and residential growth of the city by inducing expansion away from areas presently congested.

(3) The City of Alameda expressed a demand for relief, pointing out that it actually suffered when the existing bridge was built, since the ferries from Alameda were subsequently eliminated and it was more difficult for residents to cross by way of the bridge than it had been by way of the ferries. Only a crossing south of the existing bridge would provide the desired relief.

(4) San Francisco expressed a desire for bringing main-line railroad trains into the city. It would not be practicable to bring them in over a high-level bridge based on Yerba Buena Island and only a crossing south of the existing bridge offers any possibilities in this regard.

4. Design Requirements.

a. Bridges. In considering clearances for the existing bridge, aviation or air transportation was not a factor. All clearances then stipulated were solely for the free movement of water-borne traffic. During recent years, the San Francisco Bay area has developed important air transportation facilities. In planning additional vehicular crossings of the San Francisco Bay, consideration must, therefore, be given not only to the free movement of surface vessels, but also to that of

air transportation, existing air installations and to proposed air strips. In this connection, the following general considerations must be taken into account in the design of proposed structures linking the San Francisco Peninsula with the East Bay area.

(1) Horizontal clearances. Horizontal navigation clearances west and east of Yerba Buena Island along alignments within the general vicinity of the present bridge should conform to those of the existing structure. In addition, where the eastern terminus would be at the Oakland Mole, it would be required that provisions be made for a navigable span over the Oakland Outer Harbor channel with a minimum horizontal clearance of 1,400 feet between fenders. Any proposed crossing with its western terminus south of Potrero Point and north of Hunter Point should provide a span over deep water with a minimum clearance of 1,500 feet. In addition, a bridge located in this area should provide secondary channels with horizontal clearances of 600 feet on each side of the main span. South of Hunter Point, a minimum clearance between fenders of 500 feet should be provided.

(2) Vertical clearance. Vertical navigation clearances west of, and immediately east of, Yerba Buena Island along alignments within the immediate vicinity of the present bridge should conform to those of the existing structure. On locations with their eastern termini at the Oakland Mole, it is likewise required that vertical clearances of 191 feet above mean lower low water be provided over the Oakland Outer Harbor channel. The vertical clearance specified should be for a minimum distance of 1,000 feet of the span. Locations south of Potrero Point and north of Hunter Point should provide vertical

cleara nces of 226 feet above the datum of mean lower low water. Locations south of Hunter Point should provide a vertical clearance over the channel of 76 feet in a closed position and 146 feet in an open position above mean lower low water.

b. Subaqueous structures. The top of any subaqueous tube structure passing through a navigation channel or within recommended navigable areas of the bay should not be less than 55 feet below the datum of mean lower low water.

c. Combination causeway-tube. The provision of a tube for the navigable opening in a combination causeway-tube construction should provide a clear channel width of 1,500 feet. The top of the tube structure, throughout the navigable channel width, should not be less than 55 feet below the datum of mean lower low water. Likewise, any combination causeway-tube construction should provide sufficient openings to avoid any material change in the effect of the tidal prism or velocities of the existing tidal currents.

d. Obstructions to existing air installations. In the planning of any crossing of the San Francisco Bay, due consideration must be given to the approach zones of the existing air installations, and to proposed air strips. The approach zones for air installations, require a strip 1,000 feet wide at the end of the runway broadening to a width of 4,000 feet at a distance of 2 miles therefrom, the center line of which is a continuation of the center line of the landing strip. The glide angle within the limits of the above specified approach zone is 40 feet horizontal to 1 foot vertical, and starts at the end of the runway. Within the approach zone no obstructions

clearance under of 22½ feet above the plane of mean low water.

Conditions south of Harbor Point should provide a vertical clearance over the channel of 35 feet in a circular portion and 34½ feet in an open position above mean lower low water.

b. Subaqueous construction. The top of any subaqueous structure passing through a navigation channel or within recognized navigable areas of this bay should not be less than 35 feet below the plane of mean lower low water.

c. Combination conveyor-tube. The provision of a tube for the navigable opening in a combination conveyor-tube conveyor-tube bridge provide a clear overall width of 1,500 feet. The top of the tube structure, throughout the navigable channel width, should not be less than 35 feet below the plane of mean lower low water. Likewise, any combination conveyor-tube construction should provide sufficient clearance to avoid any restrictive change in the stream, or the tidal prism or velocities of the existing tidal currents.

d. Obstructions to existing air navigation. In the planning of any structure of the San Francisco Bay, the obstructions must be given to the approach zones of the existing air navigation, and to recognized air routes. The approach zones for air navigation requires a width 4,000 feet wide at the end of the runway beginning at a width of 4,000 feet at a distance of 5 miles therefrom. The centerline of which is a continuation of the center line of the landing strip. The glide angle within the limits of the above approach zone is 40 feet horizontal to 1 foot vertical, one mile at the end of the runway. Within the approach zone no obstructions

whatsoever are permitted to protrude above the specified glide angle plane.

e. Grades. Grades for all structures and approaches thereto should conform to the most economical grade for the specific traffic in conformance with recognized engineering practice.

f. Structure design. The structure design should conform to recognized standard specifications for major structures and follow in every respect recognized and accepted engineering practices.

g. Road clearances for tubes:

(1) The vertical clearance above the crown of the roadway should not be less than 14 feet.

(2) Roadway widths should be multiples of the minimum single 11-foot traffic lanes.

5. Criteria Adopted. In view of the previous discussion, the Board established the following criteria on which to base its solution:

a. Serves present pattern of traffic reasonably well and provides for probable future traffic, with due consideration for probable changes in points of origin and destination.

b. Discharges vehicular traffic into areas providing, now and in the future, easy, rapid dispersion of traffic between the crossing and the central business district in San Francisco and the center of demand on the east side of the bay over existing or definitely planned arterials.

c. Provides minimum interference with national defense.

d. Provides minimum interference with navigation.

e. Permits amortization within a reasonable period of time without undue reduction in tax rolls.

moreover are permitted to proceed above the operation grade angle

planes.

5. Curbs. Curbs for all structures and approaches should

accord to the most economical grade for the specific structure

in conformance with recognized engineering practice.

6. Structure design. The structure design should conform

to most recent standard specifications for highway structures and follow

in every respect the adopted and accepted engineering practices.

7. Road clearances for bridges:

(1) The vertical clearance above the crown of the roadway

should not be less than 14 feet.

(2) Roadway width should be adequate for the minimum

single 12-foot traffic lanes.

8. Criteria adopted. In view of the previous discussions, the

Board established the following criteria in which on long-term evaluation,

a. Serves present needs of traffic economically and

provides for probable future traffic, with due consideration for

probable changes in points of origin and destination.

b. Transports vehicular traffic from where present, now and

in the future, safely, avoid diversions of traffic around the existing

and the central business district in and through and the center of

Cheyenne on the most side of the but other structures or functionally inadequate

materials.

c. Provides minimum interference with existing business.

d. Provides minimum inconvenience with existing.

e. Provides maximum utility to cost, with due of the

minimum value restriction in the future.

6. Considerations Adopted. The Board also felt that the following were special considerations which should be given weight in arriving at the solution:

a. Is an appropriate component of an overall general plan providing for cross-bay traffic over an extended period of years.

b. Considers the desires of the City of San Francisco for a location that would stimulate the commercial and residential growth of the city by inducing expansion to the south, away from the present congestion.

c. Provides relief for the City of Alameda.

d. Provides possibility for future inclusion of railroad facilities.

VIII. POSSIBLE LOCATIONS.

1. Each side of the bay can be divided geographically into four natural areas which suggest themselves as possible locations for an additional crossing:

San Francisco Side	East Bay Side
Hunter Point Area	Bay Farm Island
Potrero Hill Area	Alameda Island
Rincon Hill Area	Oakland Mole Area
Telegraph Hill Area	Key Mole Area

2. Since, as discussed in Chapter XII, 2 b, a crossing from the Hunter Point area to Bay Farm Island would not solve the present problem, a crossing between these two locations can be eliminated from further consideration. A crossing originating in the Potrero Hill area would not be economically feasible because of its extreme length, unless it terminated on Alameda Island. On the other hand, a crossing springing from the Rincon Hill area, or the Telegraph Hill area could connect with

either the Key Mole or the Oakland Mole via Yerba Buena Island. There are, therefore, five general locations that should be considered for another crossing of the bay:

a. Potrero Hill to Alameda.

b. Rincon Hill to Oakland Mole.

c. Rincon Hill to Key Mole.

d. Telegraph Hill to Oakland Mole.

e. Telegraph Hill to Key Mole.

IX. LIMITATIONS AS TO TYPE AT POSSIBLE LOCATIONS.

1. Each of the above locations would place certain limitations on the types of crossings that would be adaptable from the standpoint of national interests (navigation or national defense). These are as follows:

a. High-level bridge. A high-level bridge from either Rincon Hill or Telegraph Hill to the Key Mole would not interfere with the national interests. However, an Oakland Mole terminus for these bridges and Alameda as a terminus for a high-level bridge, springing from the Potrero Hill area, would not be acceptable from the standpoint of national defense since high structures at these locations would interfere with flight operations at the Alameda Naval Air Station. In addition, as discussed in Chapter X, the foundation conditions at the Oakland Mole are not suitable for the construction of piers for a heavy high-level bridge.

b. Low-level bridge. The construction of a continuous low-level bridge with draw or lift span at any of the above locations would be untenable from the standpoint of national interests, since any

crossing located northerly of Hunter Point must permit unhindered passage of both commercial and naval vessels of all types and sizes. In addition, any damage which would render inoperative a draw or lift span would isolate the South Bay and San Francisco Naval Shipyard at Hunter Point.

c. Dams and Causeways. A dam or continuous causeway with locks would not be acceptable at any of the above locations from the standpoint of both navigation and national defense for the reasons explained in the discussion of the Reber Plan. Chief among these are reduction of the tidal prism with consequent adverse effect on the bar at the entrance to the bay and on existing channels, interference with port facilities and with the movement of vessels, tremendous expenditures required for relocation of Naval installations, and vulnerability of the necessary locks.

d. Continuous Tube. A continuous subaqueous tube at any of the above locations would be acceptable from the standpoint of the national interests. A continuous tube for automotive vehicular traffic would require the erection of several ventilating towers in the bay. These would present obstructions to navigation. However, at a Rincon Hill-Key Mole location, these ventilating towers could be placed adjacent to the piers of the present bridge where they would not add to existing obstructions. A continuous tube used exclusively by rapid-transit electric suburban trains would probably require towers only at the entrances and would, therefore, not add to existing obstructions in the bay.

e. Combinations. Combinations of the above types of crossings, including solid-fill causeway and tubes, low-level fixed bridge or

trestle-causeway and tubes, or floating bridge and tubes, would be acceptable, subject to the restrictions that follow, at any of the above locations from the standpoint of national interests.

2. In order to preserve the present depths of water at existing piers and to prevent additional silting of existing channels, the design should not unduly restrict the tidal flow in the bay and, in order not to interfere unduly with navigation, it should not appreciably increase tidal velocities in navigation channels. For these reasons, any combination crossing located north of a general line between Rincon Hill and the mouth of the Oakland Estuary should provide an acceptable navigation channel along each side of the bay; and any combination south of this line should provide a single acceptable navigation channel so placed as to preserve the tidal flow along the pierhead line on the west side of the bay.

X. FOUNDATION CONDITIONS IN SAN FRANCISCO BAY.

1. The Department of Public Works of the State of California contracted for wash borings at the locations of the various crossings that that Department proposed and at locations requested by the Board. Logs of all borings were furnished the Board when completed. The information obtained was plotted and is included in Appendix No. 11, Figures 2 to 10, inclusive.

2. This record of boring data provides a general conception of the subterranean conditions in San Francisco Bay. Although the information is not conclusive as to specific foundation conditions, the data indicate conditions sufficiently for the purposes of the Board.

3. The required foundation conditions differ materially for the various types of crossings that have been proposed. On the one hand, firm foundation materials are necessary for a heavy high-level bridge while, on the other hand, materials considerably less firm are suitable for a subaqueous tube.

4. West of Yerba Buena Island, foundation conditions along the boring lines from both Telegraph Hill and from Rincon Hill indicate that rock foundations may be encountered at a reasonable depth. East of Yerba Buena Island along those lines that parallel the existing San Francisco-Oakland Bay Bridge, foundation conditions are similar to those which were encountered in the erection of the present structure and suitable materials for bridge piers would be reached at comparable depths. The investigation reveals that those lines to the Oakland Mole east of Yerba Buena Island do not provide suitable foundation conditions at any reasonable depth.

5. Boring information along the line from the vicinity of Twentieth Street to Alameda, and along the line from Candlestick Point to Bay Farm Island is inadequate. However, a review of the information shown on Figures 8 and 9 in Appendix 11 indicates that suitable materials for heavy foundations along these alignments would be encountered between elevation -250 and -320.

6. The borings along the line the Board considered for a combination causeway-tube, indicated on Figure 10 in Appendix 11, show fairly uniform conditions throughout its length. The firmer materials are reached at reasonable depths averaging approximately -100 below the datum of mean lower low water. The foundation materials encountered along this general alignment are suitable for the construction of a

combination open causeway-tube and are reached at a reasonable depth below the datum of mean lower low water. The tube section providing the navigation channel does not require very firm foundation conditions, except for the islands at each end which anchor the tubes and an adequate foundation for these can be obtained. For the tubes proper, since the problem is primarily one of overcoming the buoyancy of the tube, high-bearing foundation materials are not necessary.

XI. ADEQUATE SYSTEM OF MASS TRANSPORTATION AS A SOLUTION.

1. Possible Methods of Solution. There are two possible methods of solving the cross-bay transportation problem. One is to reduce the demand on the existing structure by substituting a system of adequate mass transportation for private automobiles. The other is to provide additional vehicular crossing facilities. In this connection, it is interesting to note that a single interior lane on the existing crossing has a capacity of 1,450 vehicles or 2,460 passengers per hour, whereas a single track of subway has a capacity of 40,000 passengers per hour.

2. Necessity for an Adequate System of Mass Transportation. The necessity for an adequate system of mass transportation becomes apparent when the serious congestion on the streets of the central business district is considered. These streets can absorb only a small amount of additional traffic and, in addition, space for street parking is becoming less and less obtainable. Accordingly, it would be well to discourage the introduction of private automobiles into this district and substitute an adequate system of rapid mass transportation for them. To be adequate, such a system should provide direct connections between San Francisco and the East Bay cities and the service should

be such that the saving of time and money would convince the traveling public of its advantages.

3. Existing system.

a. The present method of mass commuter travel between the East Bay and San Francisco is by the Key System. This system necessarily has a slow running time due to the fact that the trains operate on city streets and are subject to the same traffic delays as is vehicular traffic. They must also run at restricted speeds on the bridge in order to keep impact loads on the structure within design limitations. In San Francisco, passengers on this system either walk to their destinations or make use of street cars, buses or taxi cabs which are also subject to normal traffic delays.

b. The average cross-bay automobile commuter presently bears a much greater out-of-pocket expense because of driving costs, tolls and parking charges than he would have if he used a mass transportation system. There is a personal equation involved here wherein the greater cost and greater convenience of using the private automobile are weighed against the less costly method of transportation furnished by the present systems. If this equation could be more nearly balanced so that the commuting public could be offered greater convenience, more rapid service and a saving in money, a system of mass transportation would be the solution.

4. Necessary Elements of an Adequate Rapid Transit System.

a. Such a system between San Francisco and East Bay cities capable of a substantial saving in time over the existing interurban train schedules must:

(1) Be free from the delays incident to surface transportation.

(2) Not be limited to low speeds required by design considerations of the crossing structures.

(3) Have adequate terminal transfer and distribution facilities.

(4) Lend itself to coordination with local rapid-transit systems in terminal communities.

b. The first of the above considerations requires that trains operate on their own rights of way uninterrupted by vehicular traffic. To provide this, either elevated tracks or subways must be used except on those particularly broad streets where it would be possible for trains to run in an open cut. Elevated trains are noisy, the structures are unsightly, and they tend to depress real-estate values. On the other hand, subways are not noisy, operate out of sight and do not tend to lower real-estate values. In fact, they may actually enhance these values, particularly at the portals. It would seem, therefore, that subways furnish the more practicable solution.

c. The second requirement probably cannot be met on high steel bridges without greatly increasing the cost of the structure. Tubes need not limit unduly the speed of trains running in them.

d. The third requirement involves modern terminal facilities well designed for ease of traveler circulation and speed of discharging and entraining passengers, together with proper connections to the local transit systems or feeder lines.

e. The fourth requirement can be met by correlation of travel points for cross-bay rapid transit with local systems. In at least one

(1) Be free from undue interference by existing transportation

(2) and be limited to low speeds controlled by design other

than that on the connecting railroads.

(3) Have adequate terminal transfer and distribution

facilities.

(4) Lend itself to coordination with local transportation

systems at terminal connections.

2. The first of the above considerations requires that trains

operate on short runs subject to day maintenance by railroad's terminal.

In particular their airport alongside tracks or railways must be used except

at those establishments where short distances where it would be possible for

trains to run in an open cut. Elevated trains are noisy, the structures

are unsightly, and they tend to depress residential values. On the

other hand, subways are not noisy, sightly and or right are do not tend

to lower land values to railway. In fact, they may actually enhance those

values, particularly on the periphery. It would seem, therefore, that

subways provide the most practicable alternative.

3. The second requirement prohibits transit to run on high

speed freight tracks or only lumbering the coast of the structures.

Cities need not limit during the speed of trains running in them.

4. The third requirement includes modern terminal facilities

well designed for ease of transfer directly and speed of disembarking

and embarking passengers. Together with routes a transition to the local

transit systems or trucks lines.

5. The fourth requirement may be met by construction of travel

points for connecting night trains with local systems. In no large cos

location in San Francisco, a local subway for collecting and distributing passengers from the interurban rapid-transit system could be so located that it would collect automobile passengers from peripheral parking garages and distribute them throughout the central business district.

5. The Effect of a Suggested System. Appendix No. 9 outlines the elements of one type of rapid-transit system which would satisfy the necessary requirements. It also presents a general estimate of cost of such a system. This system could be constructed in several stages, the completion of each of which would result in some saving in time of travel. The initial stage of construction would also permit the removal of the interurban tracks from the lower deck of the existing bridge, thereby increasing its capacity by over 1,000 vehicles per hour in each direction. This would postpone the date when the existing bridge would again become congested but would require the construction of additional distribution facilities at each end of the bridge. Each successive stage with its saving in travel time would probably not only divert more commuters from the use of private automobiles to the use of the rapid-transit system but would also discourage the use of private automobiles in general in the congested areas of all communities it serves.

6. Organization of a Comprehensive Rapid Transit System. A comprehensive rapid transit system completely integrated with the mass transportation of the terminal communities would require a great deal of organization and would give rise to many legal problems. The autonomy of the various communities must be considered as well as

necessary revisions of existing franchises and possible damages to existing investments of private capital. Complete coordination of the thinking of the terminal communities would be required in order to construct a comprehensive system and legislative authority would probably be required for public financing if it should not be financially attractive to private enterprise. It is considered that this completely integrated system of mass transportation for solving the cross-bay commuter problem would probably be implemented best by the formation of a transportation authority or district.

7. Conclusions.

a. The Board concludes that a rapid-transit system utilizing a centrally located tube for crossing the bay should be a component of a comprehensive long-range plan to solve the cross-bay transportation problem.

b. It must be realized that there would continue to be a great deal of vehicular traffic between the bay communities and that a substantial portion of the users of private automobiles would never be enticed away from their own vehicles. Also because of the lack of concerted public demand for such a system, the inherent delays attendant upon its organization, and because it would not solve the transbay problem in its entirety, the immediate solution to the problem is the construction of a second vehicular crossing. However, the cross-bay transportation problem cannot be solved by indefinitely continuing to add crossings for vehicular traffic alone, and steps should be taken now to foster the development of an adequate bay area rapid-transit system as a vital element of the long range solution to the problem.

XII. SOLUTIONS PRESENTED.

1. Tabular Summary.

a. A total of twenty-nine plans and two suggestions were presented to the Board as solutions to the transbay transportation problem. They represent a variety of types of construction in various locations. They are analyzed below in light of the criteria adopted by the Board. The details of each, as presented to the Board, are contained in appendices as follows:

Appendix No. 5

Plan No. 1 - The Reber Plan. Solid mole construction with ship locks and fresh-water lakes.

Appendix No. 6

Plans No. 2 and No. 3 - Joint Army-Navy Board 1941. A high-level bridge and a low-level bridge.

Appendix No. 7

Plans No. 4 to No. 13, inclusive, - Plans of the California State Department of Public Works. Eight of these are high-level bridges, one low-level bridge and one continuous tube.

Appendix No. 8

High-Level Bridges

Plans No. 14, 15, 16 by John W. Little

Plan No. 17 by James J. Walsh

Plan No. 18 by Andrew J. Pagano

Tubes

Plan No. 19 by T. A. Tomasini

Plan No. 20 by Norman W. Mohr

Solid Causeways and Ship Locks

Plan No. 21 by Sidney V. Dennison

Plan No. 22 by Fred J. Drake

Plan No. 23 by Taggart Aston

Combination Tubes with Various Low-Level Structures

Plan No. 24 by Taggart Aston

Plan No. 25 by L. J. Nishkian

Plan No. 26 by F. E. Bonner

Plan No. 27 by Cleve F. Shaffer

Plan No. 28 by Loring P. Rixford

Special

Plan No. 29 by G. R. Bolander. High-speed monorail interurban transportation supported on brackets from the present bridge.

b. In addition, two suggestions were presented which, while not plans in themselves, have a bearing on the problem and are included with the plans. These were presented by Mr. R. S. Chew and Mr. Andrew P. DeBernardi.

2. Special Solutions.

a. The Reber Plan.

(1) A diagram of the Reber, or San Francisco Bay, Plan appears on the following page. It consists essentially of two earth- and rock-fill dams (or moles) across San Francisco Bay. The lower dam or mole would connect San Francisco and Alameda counties, and the upper mole would connect Marin and Contra Costa counties. In addition, a hydraulic fill would be made in the shallows on the east shore of the

bay with a ship channel along its east side extending from the City of Alameda to Pinole Point. The construction of the two moles would dam off the upper and lower arms of San Francisco Bay, transforming each into a fresh-water lake which would be connected by a ship channel dredged behind the fill paralleling the Berkeley shore. The plan contemplates ship locks in the fill located directly opposite the Golden Gate. Their function would be to pass ships between the main portion of the bay and the channel leading to the upper and lower lakes. The channel would be one-half mile wide in its main portion and 660 feet in the remaining portions.

(2) The San Francisco terminus of the southern dam would be located just south of the present San Francisco-Oakland Bay Bridge. The dam would run in a northeasterly direction to a point just opposite the Oakland middle harbor as a solid type of causeway for its entire length except for the 660-foot channel adjacent to the Oakland shore. The author indicated that the dam could be made as wide as desired. In the plan submitted to the Board, it is shown as 2,000 feet wide and 4 miles long.

(3) The northern dam would extend from Castro Point to San Quentin Point. It would be 600 feet wide and about 4 miles long. This dam would act as a spillway for flood waters from the Sacramento River system and a reinforced concrete causeway would be constructed on it to provide rights of way for highway and railroad traffic.

(4) Tubes would be provided under the narrowed portion of the ship channel opposite the present Port of Oakland to permit highway and rail transportation to enter and leave San Francisco across the south mole.

(5) It is claimed that construction of the above features would provide two lakes with an aggregate area of 280,000 acres (120,000 acres in the lower lake and 160,000 acres in the upper lake), and, by reclamation, 20,000 acres of land.

(6) In addition to providing more adequate means of transportation, including direct rail connections, for the City of San Francisco, the proponents of the plan claim that a great number of benefits, many of which are beyond the purview of this Board, would result from its execution.

(7) The following is a brief analysis of the effect of the plan on the local economy and industry, its economic feasibility, and its influence on national interests.

(8) Effect of the Plan on the Local Economy and Industry.

(a) Transportation.

(1) In the report submitted to the Board, it was indicated that the 2,000-foot wide south mole would provide a super freeway consisting of six to eight four-lane roads connecting San Francisco with Alameda County as well as adequate space for main-line railroad connections, including the necessary switching and siding facilities.

(2) Traffic studies by the Board indicate that none of the terminal areas in San Francisco offer a street pattern, even when improved within practical limits, that could absorb, at a maximum, more than four additional lanes of cross-bay traffic in each direction. So, while the proposed super freeway would provide some 32 highway lanes, the bottleneck of the city streets would prevent use of more than a small

number of them; and while the dam could carry many lanes of traffic, it would provide no more lanes that could be used, than a bridge at the same location.

(3) In order to bring trains on to the mole, consideration must be given to the ruling grade. The preferred railroad grade is 0.5 per cent. However, assuming a 1 per cent maximum permissible grade with the channel clearances indicated in the plan as submitted, a tunnel a little less than four miles long (approximately the width of the Bay at this point) would be required in order to carry the trains under the navigation channel. Such a tube would start its descent in the vicinity of Peralta and 7th streets in Oakland and would come to grade on the mole about half way across the Bay. So the main lines of the railroads would make use of only half of the surface of the mole, and, in order to clear the navigation channel, would have to cross a major portion of the bay in costly tubes.

(4) From the above, it is concluded that the Reber Plan would offer no greater relief to automobile vehicular congestion than a high-level bridge at the same location, but that it would provide railroad connections into the City of San Francisco, although at great expense.

(b) Water Conservation.

(1) The proponents of the plan claim that the North and South arms of the Bay would be converted into fresh-water lakes which would serve as reservoirs for supplies of water that would be more than adequate for the need of the entire bay area.

(2) This purported advantage was refuted by much testimony during the public hearings, particularly from representatives of the Bureau of Reclamation and the State Division of Water Resources, as well as from several consulting engineers retained to protect local interests at the hearings.

(3) The State of California has adopted a comprehensive State Water Plan. During the investigation leading to its adoption, there was a great deal of agitation for the construction of a salt-water barrier at some point below the confluence of the Sacramento and San Joaquin rivers. The proposed barrier was the object of very exhaustive and detailed investigations by the State at that time. In addition, the San Francisco District Engineer, War Department, commented on the proposal in various reports to the Chief of Engineers. These investigations and reports concluded that a salt-water barrier was not economically feasible and that, in fact, a barrier located anywhere below Carquinez Strait would result in a waste of water rather than a saving. Therefore, water would have to be diverted from present uses in accordance with the State Water Plan or large quantities of cyclic storage would have to be provided in the mountains in order to maintain the upper and lower arms of the Bay as fresh-water lakes. In either case, the advocates of the State Water Plan feel that this water could be better used for the multiple purposes contemplated.

(4) None of the claims of water conservation by the proponents of the Reber Plan have been documented by mathematical analysis or engineering study. Separate studies by the Board and

examination of the reports of the State and Federal agencies confirm the fact that the Reber Plan would require large quantities of fresh water from surface storage elsewhere in order to maintain the upper and lower arms of San Francisco Bay as fresh-water lakes.

(5) Authorities are agreed that California's ultimate maximum population is dependent upon available water and that the misuse of water would have a restricting effect upon the growth of the State's population and would prevent attainment of the full productive capacity of the State.

(6) The Board concludes that the Reber Plan would misuse fresh water and would retard the full future economic development of Northern California.

(c) Land Reclamation and Utilization.

(1) The proponents of the Reber Plan claim that the dams and fill would provide 20,000 acres of new land, and that by creation of this land, shoal areas now present in the bay would be eliminated. This latter claim seems to be made without consideration of the suitability of this material as fill.

(2) In testimony before the Board, the State Board of Harbor Commissioners and the Commissioners of the Port of Oakland, indicate that there are presently available large areas of land for water-front development, and that no need exists for the lands which would be created by the Reber Plan. Large areas of the San Francisco water-front are still undeveloped due to the adequacy of existing water-front facilities or the unattractive financial returns to be obtained from developing new facilities. The Port of Oakland, in its planning, has projected over the years a major development of

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(4) Authorities are agreed that California's ultimate maximum population is dependent upon available water and that the misuse of water would have a restricting effect upon the growth of the State's population and would prevent attainment of the full productive capacity of the State.

(5) The Board concludes that the Reber Plan would misuse fresh water and would retard the full future economic development of Northern California.

(c) Land Reclamation and Utilization.

(1) The proponents of the Reber Plan claim that the dam and fill would provide 80,000 acres of new land, and that by creation of this land, about crops now present in the bay would be eliminated. This latter claim needs to be made without consideration of the suitability of this material as fill.

(2) In testimony before the Board, the State Board of Harbor Commissioners and the Commissioners of the Port of Oakland, indicate that there are presently available large areas of land for water-front development, and that no need exists for the lands which would be created by the Reber Plan. Large areas of the San Francisco water-front are still undeveloped due to the adequacy of existing water-front facilities or the unattractive financial returns to be obtained from developing new facilities. The Port of Oakland, in its planning, has projected over the years a major development of

that Port designed to meet the needs for more modern and additional port facilities as they arise. It was stated that these facilities, coordinated with existing facilities and services already available, could be constructed at substantial savings in cost over those contemplated in the Reber Plan. It was further stated by the Port of Oakland authorities that large areas of highly successful, modern, efficient, and war-tested facilities would be scrapped by the Reber Plan.

(3) The Reber Plan contemplates a water level in the fresh-water lakes of 9.0 feet above mean lower low water. During the public hearings, a great deal of apprehension over this feature was voiced by the representatives of the land owners in the Delta of the Sacramento and San Joaquin rivers. The delta region comprises some 500,000 acres of valuable and highly productive farm land. The maintenance of the water level of the Reber Plan would inundate substantial portions of this valuable land due to the physical impossibility of providing adequate levee systems on the peat foundations so prevalent throughout this delta region. Such a water level would not only cause inundation and require extensive levees in the delta area, but in other areas as well. Throughout the Bay area, extensive modifications, alterations and replacements of all existing sewage and drainage systems would be required along the shores of both proposed lakes. The consulting engineer for Alameda County estimated that funds in the amount of $240,000,000 would be required for flood-control measures in the cities of that county alone (Appendix No. 17). The State Engineer (Bulletin No.28) estimated that, for a water level of 3 feet above mean sea level, which is 2 feet below the level of the Reber Plan,

that Corps designed to meet the needs for more reliable and additional pure facilities in that region. It was stated that these facilities, coordinated with existing facilities and services already available, could be accomplished at substantial savings in cost over those contemplated in the Water Plan. It was further stated to the Corps of Engineers authorities that Corps funds spent on behalf of highly economical, modern, efficient, and worthwhile facilities would be overlapped by the Water Plan.

(3) The Water Plan establishes a water level

in the Lake-Water Lake of 70.0 feet above mean lower low water. During the public hearings, a great deal of apprehension over this feature was voiced by the representatives of the land owners in the Delta of the Sacramento and San Joaquin rivers. The delta region embraces some 500,000 acres of valuable and highly productive farm land. The maintenance of the water level of the Water Plan would immediately create serious problems of this valuable land due to the physical impossibility of providing adequate farm drainage in the particular areas as presently throughout this delta region. Such a water level would not only cause inundation and require extensive levees in the delta area, but in other areas as well. Throughout the bay area, extensive subdivisions, industries and expenditures of air conditioning energy and drainage systems would be required along the shores of both proposed lakes. The consulting engineers for Alameda County estimated that funds in the amount of $200,000,000 would be required for flood-control measures in the cities of that county alone (Appendix Sec. 1?). The Delta Committee (Bulletin No. 27) recommended that, for a water level of 5 feet mean sea level, which is 2 feet below the level of the Water Plan,

$100,000 annually would be required for additional seepage pumping in the delta region alone.

(4) The County of Santa Clara, in its presentation, indicated its present difficulties with floods in the lower regions of the county, and viewed with alarm any increase in water levels and the consequent more devastating effect of any floods on the valuable agricultural and industrial lands of that county. The City Engineer of Stockton concurred in the objections of the delta region to the Reber Plan and noted the necessity for increased pumping of sewage and storm waters and pointed out that the large areas of the City of Stockton would be subject to inundation.

(d) Sanitation.

(1) The transformation of the upper and lower arms of the bay into lakes would present a very expensive problem from the standpoint of sewage and waste disposal. At present, the communities and industries contiguous to the bay area secure a great deal of natural purification of their wastes by virtue of the large quantities of water available for dilution by the existing tidal prism. If this tidal prism were no longer available, additional treatment would be necessary.

(2) A change-over from a tidal system to a stationary lake system for disposal would require alteration of the existing regional scheme of bringing sewage effluent to a few centralized points where tidal factors are most favorable for dispersion. It can be expected that, as contrasted with the few regional sewage-disposal plants around the bay, now envisaged, the shores of the lakes would be dotted

$100,000 annually would be required for additional sewerage planning in the delta region alone.

(4) The County of Santa Clara, in its presentation, indicated its present difficulties with floods in the lower regions of the county, and stated that these difficulties are increasing in both levels and the concomitant have detrimental effects of any floods on the valuable agricultural and industrial lands of that county. The city engineer of Stockton commented in the discussions of the delta region on the Feather River and stated the necessity for increased pumping of sewage and storm waters and pointed out that the large areas of the City of Stockton would be subject to inundation.

(d) Conclusion.

(1) The transportation of the upper and lower ends of the bay into Inner Delta presents a very exclusive problem from the standpoint of sewage and waste disposal. At present, the communities and industries contiguous to the City also have a great deal of natural purification of their sewage by virtue of the large quantities of water available for dilution by the existing tidal prism. If this tidal prism were no longer available, additional treatment would be necessary.

(2) A diversion from a tidal system to a stabilizing fresh-water one would result in alteration of the existing regional economy of treating sewage effluent to a few centralized points where distribution is most favorable for dispersion. It can be expected that, as contrasted with the flow regional sewage-disposal plants around the bay, now envisaged, the sewers of the future will be located

with a large number of exceedingly complex sewage-treatment plants, consuming large areas of land that would adversely affect a large surrounding area. The problem of the safe location of future water intakes in relationship to points of sewage disposal would also be created.

(3) This problem is a very major one in any consideration of the Reber Plan. A comparison with a somewhat comparable situation is the lower arm of Lake Michigan in the vicinity of Chicago. Here a dense industrial population is concentrated in a comparable area on a much larger body of water which must be used for waste disposal and also water supply. Conditions in this area have grown increasingly acute with population and industrial growth, necessitating enormous expenditures for both safe water supply and adequate waste disposal. The City of Chicago, as a measure of self protection, has reversed the flow of the Chicago River and diverted large quantities of Lake Michigan water into it to remove possible pollution of its water supply by the discharge of its sewage. Even with these precautions, extensive additiona to Chicago's purification works have recently become necessary.

(4) The State Department of Public Health affirmed that the "construction of dams across San Francisco Bay to create large inland fresh-water lakes would greatly magnify the sewage-disposal problems of all the communities around San Francisco, extending at least from Antioch on the east to San Jose on the south and to San Francisco on the west . The effect would reach inland as far as Suisun and Fairfield and possibly to Stockton, and as far north as Napa."

with a large number of exceedingly complex sewage-treatment plants, consuming large areas of land that would adversely affect a large surrounding area. The problem of the safe location of future water intakes in relationship to points of sewage disposal would also be unsolved.

(3) This problem is a very major one in any consideration of the Ryder Plan. A comparison with a somewhat comparable situation is the lower end of Lake Michigan in the vicinity of Chicago. Here a dense industrial population is concentrated in a comparable area on a much larger body of water which must be used for waste disposal and also water supply. Conditions in this area have grown increasingly acute with population and industrial growth, necessitating enormous expenditures for both safe water supply and adequate waste disposal. The City of Chicago, as a measure of self protection, has reversed the flow of the Chicago River and diverted large quantities of Lake Michigan water into it to see to possible pollution of its water supply by the discharge of its sewage. Even with these precautions, extensive additions to Chicago's purification works have recently become necessary.

(4) The State Department of Public Health affirmed that the "construction of dams across San Francisco Bay to create large inland fresh-water lakes would greatly magnify the sewage disposal problems of all the communities around San Francisco, extending at least from Antioch on the east to San Jose on the south and to San Francisco on the west. The effects would reach inland as far as Suisun and Fairfield and possibly to Stockton, and as far north as Napa."

(5) In one area of the bay region alone, namely, Santa Clara County, the increased expense of waste treatment would be very high, and , were industry forced to meet this burden, it would either shift the bases of its operation or have to pass on the increased costs to the consuming public.

(6) The Board concludes that the Reber Plan would greatly increase the complexity and cost of the sewage and waste-disposal problems throughout the areas bordering on the proposed lakes.

(e) Industries.

(1) The adoption of the Reber Plan would have a very widespread effect on existing industries and the existing industrial pattern in the bay region.

(2) The southern shores of San Francisco Bay have been the scene of a major industrial development based upon the solar evaporation of salt water. The resultant salt and allied industries represent an investment of approximately $20,000,000. These industries would be eliminated entirely if the lower arm of the Bay were made into a fresh or brachish water lake. At the public hearings, a great deal of adverse testimony on the Reber Plan was introduced by the various salt companies through their consultants. The protest by one salt company expressed the opinion that the elimination of this salt industry would also have a dampening effect on the industrial development of the entire west coast.

(3) In addition to the destruction of this major industry, as indicated above, the Reber Plan would have a definitely adverse effect upon the operations of the refineries in the Richmond area. The construction of one element of the Reber Plan would

(1) In one area of the Bay region alone, namely, San Mateo County, the increased expense of waste treatment would be very high, and, were industry forced to meet this burden, it would either shift the burden of the operation or have to pass on the increased cost to the consuming public.

(2) The Board concludes that the Baker Plan would partially increase the complexity and cost of the sewage and waste-disposal problems throughout the areas bordering on the proposed lake.

(c) Industries.

(1) The adoption of the Baker Plan would have a very widespread effect on existing industries and the existing industrial patterns in the Bay region.

(2) The southern shores of San Francisco Bay have been the scene of a major industrial development based upon the sales organization of such water. The resultant salt and allied industries represent an investment of approximately $20,000,000. These industries would be eliminated entirely if the lower end of the Bay were made into a fresh or brackish water lake. At the public hearings, a great deal of extensive testimony on the Baker Plan was introduced by the various salt companies showing their apprehensions. The protest by one salt company expressed the opinion that the elimination of this salt industry would also have a damaging effect on the industrial development of the entire West coast.

(3) In addition to the destruction of this major industry, as indicated above, the Baker Plan would have a definitely adverse effect upon the operations of the refineries in the Richmond area. The construction of one element of the Baker Plan would

cut in half the existing refinery of the Standard Oil Company of California and the north dam would retard the distribution of its petroleum products by denying ready shipping access to the company's existing facilities. A similar statement objecting to the Reber Plan was entered by the Tidewater Associated Oil Company.

(4) A large number of industries, not including the fishing industry, presented their objections to the Reber Plan. A representative list of these industries is given below. The gist of their objections was based upon the disruption of the economy of the bay region which has been planned around the existing natural topography.

American Salt Company	Hooker Electro-Chemical Co.
Leslie Salt Company	Rheem Manufacturing Co.
Marine Magnesium Products Co.	Johns Manville Co.
Norton Salt Company	Fibreboard Products Co.
Oliver Bros. Salt Company	Pacific American Steamship Assn.
Plant Rubber & Asbestos Co.	Pacific American Tankship Assn.
Westvaco Chemical Products Co.	Moore Dry Dock Co.
Dow Chemical Company	Contra Costa County Boat Owners Assn.

(5) The Federal and State agencies concerned with the safeguarding of the fishing industry viewed the far-reaching effects of the Reber Plan on the fisheries in the San Francisco Bay area with alarm at the public hearings. They stated that the salmon run would be reduced materially, if not entirely destroyed. It was estimated that the construction of the Reber Plan would result in a loss of $16,000,000 annually to fisheries alone.

(6) A great deal of the value of the fisheries in this area is based upon migratory fish. These migratory fish, in order to carry on their life processes annually migrate to fresh water, normally consuming a considerable period of time in this migration.

out in half the existing refinery of the Standard Oil Company of California and the north dam would reduce the distribution of its petroleum products by denying ready shipping access to the company's existing facilities. A similar statement objecting to the Ruber Plan was entered by the Tidewater Associated Oil Company.

(4) A large number of industries, not including the fishing industry, presented their objections to the Ruber Plan. A representative list of these industries is given below. The gist of their objections was based upon the disruption of the economy of the bay region which has been planned around the existing natural topography.

American Salt Company
Leslie Salt Company
Morton Salt Company
Diamond Crystal Salt Company
Plant Rubber & Asbestos Co.
Western Industrial Products Co.
Dow Chemical Company
Ruber Electro-Chemical Co.
Shell Manufacturing Co.
Fiberboard Products Co.
Pacific American Shipping Assn.
Pacific American Tankship Assn.
Moore Dry Dock Co.
Contra Costa County Fast Owners Assn.

(5) The Federal and State agencies concerned with the safeguarding of the fishing industry viewed the far-reaching effects of the Ruber Plan on the fisheries in the San Francisco Bay area with alarm at the public hearings. They stated that the salmon run would be reduced materially, if not entirely destroyed. It was estimated that the construction of the Ruber Plan would result in a loss of $16,000,000 annually to fishermen alone.

(6) A great deal of the value of the fisheries in this area is based upon migratory fish. These migratory fish, in order to carry on their life processes annually migrate to fresh water, normally consuming a considerable period of time in this migration.

The Reber Plan would change the conditions under which these fish would migrate and it is questionable whether the fish would survive.

(7) Of perhaps even greater importance from a purely monetary standpoint (from sport-fishing revenues) as well as food value, would be the loss in the shad and striped bass fisheries. The food habits of both of these fish are adjusted to existing delta conditions, and a transition of these conditions from salt to fresh water, with the consequent destruction of existing forms of microscopic organisms, would very likely be fatal to these fish.

(8) The interference with these established Bay area industries would be unacceptable from the viewpoint of the local economy.

(f) Conclusions with Respect to Local Economy and Industry. From all of the foregoing, the Board concluded that the Reber Plan would retard the economic development of the Bay area and result in dislocation of industry.

(g) Economic Feasibility.

(1) Estimates of the cost of the Reber Plan, including the resultant damages, vary over a wide range. A rough, independent study of the major factors by the Board indicated that the direct cost of the plan would be at least $415,000,000, including damages to contiguous property, amounting to approximately $50,000,000. The opinion of the Alameda County Committee (Appendix No. 17) was that the cost would be as high as $1,500,000,000.

(2) In addition to the direct cost of the project, consideration must be given to the indirect costs, some of which are tangible and capable of monetary assessment and others of which are

The Rohner Plan would change the conditions under which these fish would migrate and it is questionable whether the fish would survive.

(7) Of perhaps even greater importance from a purely monetary standpoint (from sport-fishing revenues) as well as food value, would be the loss in the wild and escaped game fisheries. The food habits of both of these fish are adjusted to existing salinity conditions, and a transition of these conditions from salt to fresh water, with the consequent destruction of estuarine forms of microscopic organisms, would very likely be fatal to these fish.

(8) The interference with these established Bay area industries would be unacceptable from the viewpoint of the local economy.

(9) Conflicting with Interests in Local Economy and Industry. From all of the foregoing, the Board concluded that the Rohner Plan would reduce the economic development of the Bay area and result in diversion of industry.

(4) Economic Feasibility.

(1) Estimates of the cost of the Rohner Plan, including the resulting damage, vary over a wide range. A rough, reconnaissance study of the major features by the Board indicated that the direct cost of the plan would be at least $215,000,000, including damages to existing property, amounting to approximately $50,000,000. The opinion of the Alameda County Committee (Appendix No. 17) was that the cost would be as high as $1,500,000,000.

(2) In relation to the direct cost of the project, consideration must be given to the intangible costs, some of which are tangible and capable of monetary assessment and others of which are

intangible, but, nevertheless, of great importance. Appendix No. 17 assesses a cost of $1,000,000,000 to these inherent damages. A partial list of the items included are as follows:

(a) Delays to navigation.

(b) Added cost of dredging San Francisco Harbor and entrances.

(c) Destruction of existing ports and port facilities.

(d) Loss of valuable water resources.

(e) Inundation of delta lands and other low-lying areas.

(f) Increased protection costs for non-inundated levee-protected lands.

(g)Increased pumping cost of drainage and sewage systems in low-lying areas.

(h) Increased cost of proper sewage and waste treatment in bay communities.

(i) Destruction and dislocation of industry.

(j) Damage to fishing industry.

(h) Conclusions with Respect to Economic Feasibility. The Board concludes that the tremendous direct cost of the project makes it economically infeasible, particularly in the light of the far reaching, excessive indirect costs also involved.

(i) Interference with National Interests.

(1) Navigation.

(a) The adoption of the Reber Plan would seriously impair the role of San Francisco as one of the major ports

intangible, but, nevertheless, of great importance. Appendix No. 17 discusses a cost of $1,000,000 to these industrial complexes. A partial list of the items included was as follows:

(a) Delays to navigation.

(b) Added cost of dredging San Francisco Harbor and entrance.

(c) Deterioration of existing docks and port facilities.

(d) Loss of valuable water frontage.

(e) Interruption of fresh lands and other low-lying areas.

(f) Increased protection costs for non-insulated low-lying lands.

(g) Increased pumping cost of drainage and storage systems in low-lying areas.

(h) Increased cost of power mains and radio transmission in bay communities.

(i) Destruction and dislocation of industry.

(j) Damage to fishing industry.

(k) Conflicts with Proposed to Powerful Feasibility.

The Board concludes that the tremendous direct cost of the project making it economically infeasible, particularly in the light of the far reaching, intangible indirect costs also involved.

(l) Interference with Natural Interests.

(m) Navigation.

(a) The adoption of the Reber Plan would seriously impair the full use of San Francisco as one of the major ports

of the world, since it contemplates the destruction of all of the facilities existing at present in the middle and outer harbors of the Port of Oakland with consequent economic loss and the necessity for the construction of substitute facilities and because it would have a definite deleterious effect upon the San Francisco Bar. The objections to the plan voiced at the public hearings included the following:

"1. The Reber Plan, by eliminating 85% of the tidal flow through the Golden Gate, will ruin the ocean entrance by allowing it to be closed by beach and bar, and will thus convert one of the major ocean gateways of the world to an experimental status;

"2. Through the elimination of tidal scour, it will greatly increase the future maintenance of interior waterways.

* * *

"4. It will place a burden of expense and delay on all shipping endeavoring to serve terminals, existing or prospective, at any point other than within a relatively small area in north San Francisco Bay which would be left on salt water."

(b) In its independent studies (Appendix No. 5) the Board arrived at substantially the same conclusions.

(c) Coast and Geodetic Survey Chart, Serial 484, gives a graphical presentation of the extremely intricate pattern of the tidal currents in San Francisco Bay. It can be readily seen that any interruption in these tidal currents, which throughout

the years have established equilibria of water depth with the configuration of surrounding topography throughout the Bay area would result in silting, and substantial quantities of money would have to be spent annually for the maintenance of navigable channels. For the northerly arm of the bay alone, this was calculated in 1933 for a proposed salt-water barrier at Richmond at $25,000 per annum during the first 25 years below the barrier and $175,000 above the barrier.

(2) National Defense.

(a) The Reber Plan sets aside extensive areas for military and naval installations. However, no indication was given of the magnitude in dollar value of the military installations which would be eliminated or made ineffectual by the adoption of the plan. Substantial portions of the national wealth have been invested in the facilities of the shipyards at Mare Island and Hunter Point. These facilities have proved their adequacy in support of the late Pacific War. If the Reber Plan were adopted, it would jeopardize the mobility of any of the fleet units at either of these shipyards.

(b) In their reply to the Board's inquiry, military and naval commanders in this area indicated the opposition to the Reber Plan and some stated that the additional military facilities proposed as one of the advantages of the plan are neither necessary nor desirable.

(c) Damage to the locks or dams by enemy action or sabotage would render impotent ships and shore facilities within the lake areas. No responsible naval commander could afford to sacrifice the mobility of his command by basing it behind dams and subjecting it to the transit of narrow channels and locks in the event

the years have established equilibria of water depth with the configurations of surrounding topography throughout the Bay area would result in silting, and substantial quantities of money would have to be spent annually for the maintenance of navigable channels. If the northerly arm of the bay alone, this was calculated in 1923 for a proposed salt-water barrier at Richmond as $25,000 per annum during the first 25 years below the barrier and $125,000 above the barrier.

(5) Matériel Defense.

(a) The Baker Plan gets rid of extensive areas for military and naval installations. However, no indication was given of the magnitude in dollar value of the military installations which would be eliminated or made ineffectual by the adoption of the plan. Substantial portions of the national yards have been invested in the facilities of the shipyards at Long Island and Hunter Point. These facilities have proved their adequacy in support of the Long Beach Yard. If the Baker Plan were adopted, it would jeopardize the mobility of any of the fleet units at either of these shipyards.

(b) In their reply to the Board's inquiry, military and naval commanders in this area indicated the opportunities to the Baker Plan and some stated that the additional military facilities proposed as one of the advantages of the plan are neither necessary nor desirable.

(c) Damage by the locks or dam by enemy action or sabotage would render important ports and shore facilities within the lake areas. No responsible naval commander could afford to sacrifice the mobility of his command by locating it behind dam and subjecting it to the hazards of narrow channels and locks in the event

of a required sortie.

(j) General Conclusion of the Board with Respect to the Reber Plan. Overwhelming opposition to the plan by State, County and City authorities, together with commercial and military interests, was presented at the public hearings. After careful consideration of this and all other factors involved, the Board has reached the conclusion that the Reber Plan would result in the dislocation of industry, is economically infeasible and is untenable from the standpoint of navigation and national defense.

b. San Francisco to Bay Farm Island Bridges (Subject of the 1941 Board Report).

(1) Pursuant to House Resolution 158, 77th Congress, first session, a Joint Army-Navy Board investigated the need and feasibility, from the viewpoint of the national defense, of constructing a bridge between Hunter Point and Bay Farm Island. The mission of this Board was different than that of the present Board. The former was directed to investigate a specific type of crossing at a specific location, whereas it is up to the present Board to select the location and type of crossing it deems best. In its report, the 1941 Board discussed two possible solutions, a high-level bridge from Hunter Point (west of Point Avisadero) to Bay Farm Island, and a low-level bridge from Double Rock (between Hunter Point and Candlestick Point) to Bay Farm Island. The conclusions of this Board are included in Part A of this report. Its syllabus stated the following:

> "The joint board of Army and Navy officers appointed to report upon a Hunter Point-Bay Farm Island bridge, pursuant to H.R. 158, dated July 23, 1941, concludes that while a bridge at the location stated is structurally feasible, such bridge is unnecessary from the standpoint of na tional

of a required width.

(3) General Conclusion of the Board with Respect to the Bakers Plan. Overwhelming opposition to the plan by state, County and City authorities, business with commercial and military interests, was received at the public hearings. After careful consideration of this and all other factors involved, the Board has reached the conclusion that the Bakers Plan would result in the dislocation of industry, is economically indefensible and is unfavorable from the standpoint of civilian and national defense.

b. Bay Crossing to Bay Farm Island Including Subject of the 1941 Board Report.

(1) Pursuant to Navy Department 1.5, 1939, Corps Engineers, First Section, a Joint Army-Navy Board investigated the feasibility, from the viewpoint of the national defense, of constructing a bridge between Hunter's Point and Bay Farm Island. The report of this Board was different than that of the present Board. The former was directed to investigate a specific type of crossing at a specific location, whereas it is up to the present Board to select the location and type of crossing it deems best. In its report, the 1941 Board discussed two possible solutions, a high-level bridge from Hunter Point (near Point Isabelle) to Bay Farm Island, and a low-level bridge from Doolittle Rock (between Hunter Point and Doolittle Point) to Bay Farm Island. The quotations of this Board are included in Part A of this report. The opinions stated the following:

"The Joint Board of Army and Navy officers appointed to report upon a bridge to Bay Farm Island (Alameda), pursuant to E.O. 1.5, dated July 23, 1941, concludes that while a bridge at the location stated is admittedly feasible, such bridge is unnecessary from the standpoint of the strict

defense. The board recommends that if a bridge at that location be authorized, it be a high level double deck bridge, springing from Hunter Point west of Point Avisadero (the tip of Hunter Point), with four traffic lanes on the upper deck and two lanes for truck traffic and two railway tracks on the lower decks, with suitable approaches at each end."

(2) The present Board concurs that the construction of either of these crossings is physically feasible. However, it recommends that any crossing at the first-named location should be a combination causeway and tube rather than a high-level bridge. The present Board concurs in the recommendation that any crossing south of Hunter Point should be a low-level bridge.

(3) An analysis of the solution recommended by the 1941 Joint Army and Navy Board (a high-level bridge from Point Avisadero to Bay Farm Island), in light of the criteria established by the present Board for an additional crossing, follows.

(4) The present Board's traffic study, Appendix No. 9, revealed that a bridge springing from the vicinity of Hunter Point and crossing to Bay Farm Island would serve only 11 percent of the present traffic. The State estimated that this figure would be as low as 5 per cent and that such traffic plus "generated" traffic would total only about 2,200,000 vehicles per year. This would be less than half the annual traffic of the Golden Gate Bridge, the cost of which was substantially less than would be the cost of a bridge in this location.

(5) Any crossing that would attract only 11 per cent of the total cross-bay traffic and which would be completed in 1954 or thereafter would not relieve the congestion on the existing bridge.

[illegible]

[illegible] The board was unable that it a bridge on [illegible] location be [illegible], or to a high level [illegible] bridge, spanning from Hunter Point west of Point Arguello (the tip of Hunter Point), with [illegible] towers on the upper deck and two lower [illegible] on the lower deck, with [illegible] approaches on both sides."

(2) The department board concurs in the construction of either of these crossings is physically feasible. However, it is commonly that any crossing at the first-named location should be a combination roadway and tube rather than a high-level bridge. The present Board a [illegible] in the recommendation that any crossing south of Hunter Point should be a low-level bridge.

(3) As to plans of the analysis recommended by the Joint Army and Navy Board (a high-level bridge from Point Arguello to Hay Farm Island), in light of the criteria established by the present Board for an [illegible] crossing, follows.

(a) The present Bonalla traffic study, applied to [illegible] reveals that a bridge spanning from the vicinity of Hunter Point and crossing to Hay Farm Island would serve only 32 percent of the present traffic. The State engineers [illegible] this figure would be as low as 5 per cent [illegible] "generated" traffic would total only about 2,200,000 vehicles per year. This would be less than half the annual traffic of the Golden Gate Bridge, the cost of which was substantially less than would be the cost of a bridge in this location.

(3) Any crossing that would serve only 32 per cent of the total cross-bay traffic and which would be completed in 1954 or thereafter would not relieve the congestion on the existing bridges.

(6) In testimony before the Board, the City of San Francisco strongly advocated that the western terminus for any new crossing be in the vicinity of Army Street. Inasmuch as the City may have to provide the arterial connections to any new crossing, their wishes in this regard should be given consideration. No future factors are apparent which would cause any radical change in the above.

(7) The Board concludes that a crossing from Hunter Point to Bay Farm Island would not serve the present pattern of traffic reasonably well or provide for future traffic.

(8) The solution recommended by the 1941 Board discharges vehicular traffic into Third Street. This artery and Potrero Avenue via Bayshore Boulevard are the only two main thoroughfares available to any traffic travelling between Hunter Point and the central business district of San Francisco. They now bear a very large portion of the heavy peninsula traffic and are very congested during peak hours. The extension of the Bay Shore Freeway north of Army Street would relieve this congestion to some extent, but even then little additional capacity would be available for the use of traffic crossing the bay during peak hours on a south crossing. This small amount might prove sufficient since only 11 per cent of the total traffic would seek this structure. However, it would prove inadequate if such a crossing were ever used to full capacity. In this latter case, an additional freeway for bringing such cross-bay traffic from Hunter Point to and beyond the Southern Pacific and other tracks south of Townsend Street and dispersing it properly before it reaches the central business district would have to be provided to make the crossing effective. Without it, a crossing landing at Hunter Point, if it were used to full capacity, would not adequately solve

(6) In testimony before the Board, the City of San Francisco strongly advocated that the machine terminal for any new crossing be in the vicinity of Army Street. Inasmuch as the City may have to provide the material connections to any new crossing, there seems to this report should be given consideration. No future factors are apparent which would cause any material change in the above.

(7) The Board concludes that a crossing from Bunker Point to Bay Farm Island would not serve the present pattern of traffic reasonably well or provide for future traffic.

(8) The solution recommended by the Joint Board directs vehicular traffic into Tubin Street. This subway and Tubinera Avenue via Bunyone Boulevard are the only two main thoroughfares available to any traffic travelling between Bunker Point and the central business district of San Francisco. They are near a very large portion of the heavy passenger traffic and are very congested during rush hours. The extension of the Bay Shore Freeway north of Army Street would relieve this congestion to some extent, but even then little additional capacity would be available for the use of traffic crossing the bay during rush hours on a rush crossing. This would result with perhaps sufficient space only 11 per cent of the total traffic would use this crossing. However, it would prove inadequate if such a crossing were ever used to full capacity. In this latter case, an additional crossing for bringing such cross-bay traffic from Bunker Point to and beyond the Southern Pacific and other tracks south of Tubinera Street and dispersing it properly before it reaches the central business district would have to be provided to make the crossing efficient. Without it, a crossing landing at Bunker Point, if it were used to full capacity, would not adequately solve

the transbay traffic problem during peak hours.

(9) This crossing would be located so far south in the bay that it would only affect a small percentage of the commercial shipping that would be required to pass under it to arrive at its destination. However, it would restrict free access of naval vessels to the northerly part of the San Francisco Naval Shipyard at Hunter Point. Here, since the report of the 1941 Board, the United States has spent many millions of dollars to develop a major naval shipyard. Additional improvements are in prospect and this facility will be of primary importance to the Navy for many years to come.

(10)Inasmuch as the State law requires that any crossing on which tolls are collected must be constructed by the State Toll Bridge Authority, it is essential that a sufficient income be insured to justify the construction of that crossing. While the financial structure of this crossing, like any other, would have to be combined with that of the existing bridge, the limited amount of traffic estimated at 2,200,000 vehicles per year, that would be attracted to it would provide such a limited income that the crossing would not bear its fair share of the overall combined costs.

(11) The Board concludes that a crossing at the locations reported on to Congress in response to House Resolution 158, 77th Congress, first session, from Hunter Point to Bay Farm Island would not provide an adequate solution to the present problem.

c. Other Solutions.

(1) General basis for discussion.

(a) The five criteria adopted by the Board against which the proposed solutions to the cross-bay transportation problem

the terminal traffic problem during peak hours.

(3) This crossing would be located so far south in the bay that it would only affect a small percentage of the commercial shipping that would be required to pass under it to arrive at its destination. However, it would restrict free access of naval vessels to the northerly part of the San Francisco Naval Shipyard at Hunter Point. Here, since the report of the 1941 Board, the United States has spent many millions of dollars to develop a major naval shipyard. Additional improvements are in prospect and this facility will be of primary importance to the Navy for many years to come.

(4) Inasmuch as the State law requires that any crossing on which tolls are collected must be constructed by the State Toll Bridge Authority, it is essential that a sufficient income be insured to justify the construction of that crossing. While the financial structure of this crossing, like any other, would have to be combined with that of the existing bridge, the limited amount of traffic estimated at 2,200,000 vehicles per year, that would be attracted to it would provide such a limited income that the crossing would not bear its fair share of the overall combined costs.

(11) The Board concludes that a crossing at the locations reported on to Congress in response to House Resolution 158, 77th Congress, First Session, from Hunter Point to Bay Farm Island would not provide an adequate solution to the present problem.

c. Other Solutions.

(1) Central Span for Discussion.

(a) The five criteria adopted by the Board against which the proposed solutions to the cross-bay transportation problem

have been judged, were discussed earlier in this report. The following discussion analyzes the other solutions presented only with respect to certain of these criteria for the reasons that follow.

(b) It may be said that, in general, any crossing located north of an Army Street, San Francisco - Webster Street, Alameda, line serves the pattern of traffic reasonably well and meets the Board's first criterion, and that a crossing south of this line will not solve the existing auto vehicular transportation problem.

(c) An analysis to determine whether or not any proposal permits easy, rapid dispersion of traffic and meets the Board's second criterion cannot be made without a detailed plan for the necessary distribution structures and a demand-capacity study of the critical streets. Such an analysis will be made only for those solutions selected for detailed study.

(d) Chapter IX discusses the limitations as to type of crossings at the various general locations in the bay area from the standpoint of navigation and national defense. Whether or not any proposed solution meets the third and fourth criteria is determined largely by the fact that it does or does not come within the limitations discussed in Chapter IX.

(e) To determine the conformity of any solution with the last criterion, a design in sufficient detail to provide a reasonably accurate estimate of cost is required. This has been done only for those solutions selected for detailed study.

(f) The following discusses the other solutions presented principally with respect to their interference with the national

have been judged, were discussed earlier in this report. The following discussion analyzes the other solutions presented only with respect to certain of those criteria for the reasons that follow:

(b) It may be said that, in general, any crossing located north of an Army Street, San Francisco - Webster Street, Alameda, line serves the pattern of traffic reasonably well and meets the Board's first criterion, and that a crossing south of this line will not solve the existing auto vehicular transportation problem.

(c) An analysis to determine whether or not any proposal permits easy, rapid dispersion of traffic and meets the Board's second criterion cannot be made without a detailed plan for the necessary distribution structures and a demand-capacity study of the critical streets. Such an analysis will be made only for those solutions selected for detailed study.

(d) Chapter IX discusses the limitations as to type of crossings at the various general locations in the bay area from the standpoint of navigation and national defense. Whether or not any proposed solution meets the third and fourth criteria is determined largely by the fact that it does or does not come within the limitations discussed in Chapter IX.

(e) To determine the practicability of any solution with the last criterion, a design in sufficient detail to provide a reasonably accurate estimate of cost is required. This has been done only for those solutions selected for detailed study.

(f) The following discusses the other solutions presented primarily with respect to their interference with the national

interests. It eliminates from more detailed study those solutions located south of the Army Street-Webster Street line and those that do not meet the third and fourth criterion of the Board. It selects those solutions that warrant further detailed study, particularly with respect to criteria No. 2 and No. 5.

(2) Bridges.

(a) Plans for fourteen bridges were submitted to the Board. Eight of these were for high-level bridges proposed by the State of California, five for high-level bridges proposed by private interests, and the remaining one for a low-level bridge also proposed by the State of California. The following is a description of these proposals with a brief analysis of each in accordance with the foregoing.

(1) Five of the State of California plans for high-level bridges spring from the vicinity of Telegraph Hill and two from Rincon Hill. All seven have a common base on Yerba Buena Island. The eastern termini of four of these are in the vicinity of the Key Mole and those of the remaining three are at the Oakland Mole. All plans provide horizontal and vertical clearances for water-borne traffic comparable to those of the present bridge.

(2) The construction of those three bridges whose eastern termini are at the Oakland Mole would not be feasible for the reasons discussed in Chapter VIII. Two of these bridges would spring from Telegraph Hill and the third from Rincon Hill. Of the remaining bridges, one would originate at Rincon Hill and the other three at Telegraph Hill.

(3) These four crossings would all satisfy the criteria adopted by the Board sufficiently to warrant more detailed analysis of their attributes.

(4) The remaining high-level bridge plan of the State of California would connect Potrero Hill to Webster Street in Alameda. This location would not be acceptable from the standpoint of the national interests for the reasons discussed in Chapter IX.

(5) The plan submitted by the State for a low-level bridge with lift span would connect Candlestick Point in San Francisco with Bay Farm Island. As already pointed out in the foregoing and in the discussion of the 1941 Board report, a crossing at this location would not provide a solution to the problem since it would not attract a sufficient portion of the total traffic demand to relieve the congestion on the existing bridge.

(6) Plans Nos. 14, 15, 16 by John W. Little

(a) The Little Plan was a long-range proposition outlining three crossings which the proponent feels would ultimately have to be constructed. However, the locations have not been adjusted to the present situation. One of Mr. Little's crossings would spring from Van Ness Avenue, San Francisco, to the vicinity of Alcatraz, from which point it would branch to Sausalito, Marin County and to Berkeley. That portion of the crossing to Sausalito is not within the purview of the Board's study. The remaining fork to Berkeley is not considered to be an acceptable solution to the present problem because of its circuitous route, consequent excessive length, and excessive cost.

(b) Another bridge would spring from Market Street, San Francisco, to Yerba Buena Island, with a solid-fill

causeway from there to the Key Mole in Oakland. This latter feature is not acceptable from the standpoint of navigation and national defense. The proponent states that a navigation channel, although not considered necessary, may be provided here. However, even with this feature, this location is not considered as satisfactory a solution as that provided by the State's bridge near the same location.

(c) The third bridge would connect 16th Street, San Francisco, with Alameda. As discussed in Chapter IX, a high-level bridge at this location would not be acceptable from the standpoint of national defense as it would interfere with flight operations at the Alameda Naval Air Station and would cut across the northwest corner of the station itself.

(d) In addition to the objections peculiar to each bridge, all have the common unacceptable features, from the standpoint of navigation and national defense, of low vertical and narrow horizontal clearances for water-borne traffic. The plans themselves give no measurements, but the included literature (Page No. 4, Appendix No. 8) indicates horizontal clearances of 625 feet and 1,050 feet with a vertical clearance of 135 feet above mean high water. The low vertical clearance was supported on the basis that the Brooklyn Bridge at New York has a height of only 132 feet. As a matter of fact, the low vertical clearance of the Brooklyn Bridge has prevented large naval vessels from entering the Brooklyn Navy Yard, necessitating diversion of these vessels to Boston. A similar situation in San Francisco should not be permitted to exist.

(7) Plan No. 17 by James J. Walsh.

(a) This plan proposed a high-level bridge south of the Army Street-Webster Street line springing from a point

just north of Hunter Point, San Francisco, on an axis in line with Bay Farm Island. At a point in the east bay, just inside the five-fathom curve, the bridge would be served by two causeways, one proceeding in a northeasterly direction toward Main Street, Alameda, with a subaqueous tube under the Oakland Estuary, and the other going east to Bay Farm Island and tying into the existing road system by means of additional sand fill around the western perimeter of the island.

(b) From the limited information available, it appears that the bridge would come undesirably close (within approximately 800 feet) to the northerly installations of the San Francisco Naval Shipyard at Hunter Point. This crossing would be in the same category as others already discussed at this general location in that it would not solve the present problem and would interfere with naval activities at Hunter Point. In addition, because of its circuitous route and excessive length, the costs involved would be excessive.

(8) Plan No. 18 by Andrew J. Pagano.

(a) This plan proposed a high-level bridge from Brannan Street, San Francisco, to the Alameda Mole with a connection to the Western Pacific mole by means of a high-level bridge across the Oakland Estuary. No vertical nor horizontal clearances for water-borne traffic either for the bay or the Oakland Estuary were presented, and, therefore, no conclusion can be drawn as to its effect on navigation. From the standpoint of national defense, it would not be acceptable as it would interfere with flight operation from the Alameda Naval Air Station and would cross the northwest corner of the station.

(b) To summarize, preliminary study by the Board indicated that those high-level bridge plans which would provide

just north of Hunter Point, San Francisco, on an area in line with Bay Farm Island. At a point in the east bay, just inside the flow-lines curve, the bridge would be served by two approaches, one proceeding in a northeasterly direction toward Main Street, Alameda, with a subpassage tube under the Oakland Estuary, and the other going east to Bay Farm Island and lying into the existing road system by means of additional sand fill around the western perimeter of the island.

(h) From the limited information available, it appears that the bridge would come adjacently close (within approximately 600 feet) to the northerly installations of the San Francisco Naval Shipyard at Hunter Point. This crossing would be in the same category as others already discussed at this general location in that it would not solve the present problem and would interfere with naval activities at Hunter Point. In addition, because of the circuitous route and extensive length, the costs involved would be excessive.

(g) Plan No. 16 by Andrew J. Hogan.

(a) This plan proposed a high-level bridge from Grand Street, San Francisco, to the already this with a connection to the Western Pacific made by means of a high-level bridge across the Oakland Estuary. No vertical nor horizontal clearances for water-borne traffic either for the bay or the Oakland Estuary were presented, and, therefore, no conclusion can be drawn as to its effect on navigation. From the standpoint of national defense, it would not be acceptable as it would interfere with flight operations from the Alameda Naval Air Station and would cross the northwest corner of the station.

(b) To summarize, preliminary study by the Board indicated that those high-level bridge plans which would provide

the most reasonable solution to the problem and which warrant more detailed analysis have all been presented by the State of California. These are as follows: Three springing from the vicinity of Telegraph Hill to the Key Mole via Yerba Buena Island and one from Rincon Hill paralleling the present bridge to the Key Mole via Yerba Buena Island.

(3) Dams and Causeways. In addition to the Reber Plan, three other crossings involving the use of dams or causeways were submitted to the Board. These are as follows:

(a) Plan No. 21 by Sidney V. Dennison.

(1) This proposed a solid causeway 1,200 feet wide under the present bridge from San Francisco to Yerba Buena Island, with ship locks installed on each side of the center bridge pier, a wye-tunnel through the island, one leg of which would lead to a causeway under the east end of the present bridge to the Key Mole, and the other to a causeway from Treasure Island to Tiburon in Marin County via Angel Island and Raccoon Strait. Ship locks would be provided in Raccoon Strait, and highway and railroad facilities on all causeways. All of the bay area beyond the solid causeways would become fresh water.

(2) This plan is similar to the Reber Plan in that it would drastically change the physical characteristics of San Francisco Bay in order to accomplish the primary object of relieving traffic congestion on the existing bridge. A complete discussion of this and other factors affecting the construction of dams and causeways, has been presented under the "Reber Plan" (Chapter XII, 2 a) and will not be repeated here. The conclusion reached with respect to the Reber Plan, "that it would result in the dislocation of industry, is economically infeasible, and is untenable from the standpoint of navigation

the most reasonable solution to the problem and which methods were detailed studies have all been presented by the Bureau of Engineering. These are as follows: These studies show the feasibility of bridges HIJK in the Key West via Lower Sugarloaf Key and Cow Pen Bight, paralleling the present bridge to Cow Key West via Upper Sugarloaf Key.

(3) Dams and Causeways. In addition to the bridge plans, there other alternate proposals involving the use of dams or causeways over which to the Keys. These are as follows:

(a) Plan No. 21 by Bishop S. Pendleton.

(b) This proposal is a dam crossing at Little Card made under the supervision of Commodore Ed Lewis Jones Island, with bridge locks provided on each side of the central dam. It is proposed through the island, one lock at Marathon, which land to a causeway under the near end of the proposed bridge to the Key West, and the other to a causeway from Marathon Island to Vaca Key. Bridges to Marathon Island and Boot Key are also provided in Pendleton Circuit, and highway and railroad facilities on all causeways. All of the Keys more beyond the solid causeway would become fresh water.

(c) This plan is similar to the Lower Keys in that it would dredge a navigable channel through the Florida Keys by using the spoil from the channel to build a highway traffic separation on the Atlantic bridge. A complete discussion of this and other features of the proposed construction of a ship canal across Key, has been presented under the "Ship Canal Project" ITT, 2 pt and will not be repeated here. The conclusion reached after consideration in the Report Board, that it would result in the depletion of the Keys, economically intolerable, and is regarded from the standpoint of navigation

and national defense" applies equally to the Dennison Plan.

(b) Plan No. 22 by Fred J. Drake. This plan proposed a solid-fill causeway south of the Army Street-Webster Street line and connecting Hunter Point between Candlestick Point, San Francisco, with Davis Street, San Leandro. It would consist of a solid fill causeway springing from the San Francisco shore, an elevated viaduct over the navigable channel for water-borne traffic and a solid-fill causeway to the San Leandro side. The causeway would have connections to Hunter Point and Bay Farm Island. No measurements are available, and no horizontal and vertical clearances for the navigation channel were submitted. The plan dismissed this important feature by stating that the elevated viaduct would be high enough for coastal steamers to proceed to Redwood City although large ocean-going vessels are also handled there.

(c) Plan No. 23 by Taggart Aston.

(1) This plan proposed a salt-water barrier in the northern portion of San Francisco Bay between points in the vicinity of Point San Pedro, Marin County, to Point San Pablo, Contra Costa County. It consisted of cylindrical, floatable crib construction sunk into position over the site of the barrier. A cut would be made through a hill saddle in the vicinity of Point San Pablo to provide a ship channel and ship locks. The highway would be carried on a viaduct over the channel cut on a five per cent grade, and railroads carried on a one per cent grade to a lift bridge over the channel.

(2) This plan was similar to the Reber Plan and the Dennison Plan in that, among other things, it changed the physical characteristics of San Francisco Bay, and is, therefore, not a desirable

and additional dolphins" applies equally to the Dumbarton Plan.

(b) Plan No. 22 by Noel A. Brown. This plan proposed a vehicular causeway south of the Navy Steam-Shovel Repair line and connecting Harbor Point between Candlestick Point, San Francisco, with Hills Street, San Leandro. It would consist of a solid fill causeway springing from the San Francisco shore, an elevated trestle over the navigable channel for water-borne traffic and a solid-fill causeway to the San Leandro side. The causeway would have connections to Harbor Point and Bay Farm Island. No measurements are available, and no horizontal and vertical clearances for the navigable channel were indicated. The plan disclosed this important feature by showing that the elevated trestle would be high enough for coastal steamers to proceed to Redwood City although large ocean-going vessels are also handled there.

(c) Plan No. 23 by Reginald Brown.

(1) This plan proposed a salt-water harbor in the northern portion of San Leandro Bay between points in the vicinity of Point San Pedro, North County, to Point San Pablo, Contra Costa County. It consisted of rectangular, floatable crib construction and tube pontoons over the site of the harbor. A cut would be made through a fill needle in the vicinity of Point San Pablo to provide a ship channel and ship locks. The highway would be carried on a viaduct over the channel cut on a five percent grade, and railroads carried on a one per cent grade to a lift bridge over the channel.

(2) This plan was similar to the Harbor Plan and the Dumbarton Plan in that, among other things, it changed the physical characteristics of San Leandro Bay, and is, therefore, not a desirable

solution. As previously stated, all types of construction involving damming off portions of the bay and the use of ship locks for navigation have the same undesirable features. These features have been discussed at length in the Reber Plan and it is not considered necessary to repeat the findings here.

(4) Continuous Tubes and Other Suggestions.

(a) Two plans were submitted to the Board embodying the use of continuous tubes for crossing the bay. These were:

Plan No. 19 by T. A. Tomasini

Plan No. 20 by Normand Winfield Mohr.

(1) Plan No. 19 by T. A. Tomasini, as originally presented, would provide a continuous subaqueous tube from the Key Route Mole in Oakland to the foot of Howard Street in San Francisco, and a subway to a terminal at 6th and Howard streets. This tube would carry two tracks for main-line railroads, and three 10-foot lanes in each direction for truck and bus traffic. An alternate route would take off from the main route near Yerba Buena Island, and run to the Southern Pacific Mole in Oakland. In oral presentation, the original plan was modified to substitute two additional tracks for interurban electric for one truck lane in each direction. Auto traffic would not be permitted to use the crossing. The estimated cost of the proposed tube, with single rail service, was $90,000,000--with double rail service, $120,000,000. No approach details were suggested. A unique feature of the plan was the proposal to finance it with private capital. Ventilating towers would be so located in navigation channels as to be masked by piers on the existing bridge, or by Yerba Buena Island.

solution. As previously stated, all types of construction involving damming off portions of the bay and the use of ship locks for navigation have the same undesirable features. These features have been discussed at length in the Reber Plan and it is not considered necessary to repeat the findings here.

(4) Continuous Tubes and Other Suggestions.

(a) Two plans were submitted to the Board embodying the use of continuous tubes for crossing the bay. These were:

Plan No. 19 by T. A. Tomasini

Plan No. 20 by Morrand Winfield Mohr.

(1) Plan No. 19 by T. A. Tomasini, as originally presented, would provide a continuous subaqueous tube from the Key Route Mole in Oakland to the foot of Howard Street in San Francisco, and a subway to a terminal at 6th and Howard streets. This tube would carry two tracks for main-line railroads, and three 10-foot lanes in each direction for truck and bus traffic. An alternate route would take off from the main route near Yerba Buena Island, and run to the Southern Pacific Mole in Oakland. In oral presentation, the original plan was modified to substitute two additional tracks for light urban electric for one truck lane in each direction. Auto traffic would not be permitted to use the crossing. The estimated cost of the proposed tube, with single rail service, was $300,000,000--with double rail service, $120,000,000. No approach details were suggested. A unique feature of the plan was the proposal to finance it with private capital. Ventilating towers would be so located in navigation channels as to be masked by piers on the existing bridge, or by Yerba Buena Island.

(a) This plan would divert all truck and bus traffic from the present bridge and, by including tracks for electric rapid-transit trains, would serve substantially to divert commuter passengers from the use of private autos to such rapid transit. It would not interfere with navigation since the top of the proposed tube at elevation -58 would be below the greatest contemplated dredging depths for the main navigation channel. The ventilating towers, being masked by piers on the existing bridge and by Yerba Buena Island, would not increase existing hazards to surface navigation. There would be no interference with air navigation. The plan would not interfere with existing military or naval installations or restrict their full use.

(b) However, the Board feels that the plan in its entirety is not a proper solution to the present problem for two main reasons: First, because of the relative high cost of the tube proper, and, second, because it is felt that the public would be reluctant to accept a ventilated tunnel for motor transportation almost three times as long as any existing vehicular subaqueous tube.

(2) Plan No. 20 by Normand Winfield Mohr, a plan originally conceived in 1927, included subaqueous tubes to Marin and Alameda counties as features of a comprehensive plan of city improvement and beautification. The tubes were originally conceived to carry as many as twelve lanes of traffic, including main-line and interurban trains and auto trucks. In bringing this plan up to date, Mr. Mohr stated that "It is planned to carry autos in special electric trains to eliminate expensive ventilation." No details were submitted and no estimates of cost were furnished. Comments on this plan are the same as those stated in the first sentence of the preceding paragraph.

(a) This plan would divert air traffic

and use traffic from the present bridge and, by installing tracks for electric trolley-type air trains, would serve substantially to divert commuter passengers from the use of private autos to such trolley-trains. It would not interfere with navigation along the top of the proposed tube, as elevation. It would be below the greatest navigational draught for the main navigation channel. The navigating bridge, being moved by place on the existing bridge and by Fields Bucks Island, would not interfere existing navigation to Boston navigation. There would be no interference with air navigation. The plan would not interfere with existing utility or power installations or restrict their full use.

(b) Moreover, the board feels that the plan in its entirety is not a proper solution to the present problem for two main reasons: First, because of the existing high cost of the tube project; and, second, because it is felt that the public would be reluctant to accept a ventilated tunnel for motor transportation, about three times as long as any existing publicly subsidized tube.

(c) Plan No. 20 by Raymond Hilsdale Hill, a plan originally conceived in 1927, included stockyards tubes to Revere and Chelsea combined as features of a comprehensive plan of city improvement and beautification. The tubes were originally conceived to carry as many as twelve lanes of traffic, including main-line and interurban trains and auto trucks. In bringing this plan up to date, Mr. Hill stated that "it is planned using a tunnel in special electric trains to eliminate objectionable ventilation." He detailed some measures and an estimation of cost from Brookline. Elsewhere in this plan are the same as those stated in the first sentence of the preceding paragraph.

(b) In addition to the 29 plans for transbay crossings presented, there were two suggestions submitted to the Board which had to do with the method of distributing traffic in downtown San Francisco, which are described in this section of the report. Those were:

Suggestion No. 1 by R. S. Chew

Suggestion No. 2 by Andrew P. De Bernardi

(1) Suggestion No. 1 by R. S. Chew does not in itself offer a definite plan for a transbay crossing, and for that reason is not included among the 29 plans previously listed. The basic features of the Chew suggestion contemplated the discouragement of commuter auto traffic by the establishment of a complete rapid-transit train system from San Francisco to the East Bay communities, and provision for better distribution of such traffic by elevated structures in the East Bay and by subway system in San Francisco. The Chew suggestion would provide a new bridge in a southerly location, and suggests a subterraneous bus terminal and auto parking garage under Telegraph Hill between Grant Avenue and Sansome Streets. The initial premise as to substitution of rapid mass transit to discourage commuter auto traffic is enlarged upon in Appendix No. 9, Traffic Study.

(2) Suggestion No.2 by Andrew P. De Bernardi was a combination tube and causeway from a terminus between Army Street and the San Francisco-San Mateo County line, and the vicinity of the Oakland Mole. The proposal would carry main-line trains descending on a one per cent grade in a depressed roadway in the center of the causeway to a tube connection under navigable channels. Vehicular traffic would be carried on level lanes outside of the depressed roadway to descend on a steeper grade to equivalent tubes. Tidal circulation

(4) In addition to the 2/1 plans for transbay crossings

presented, there were two suggestions submitted to the Board which had

to do with the matter of distributing traffic in downtown San Francisco,

which are described in this section of the report. These were:

Suggestion No. 1 by H. A. Gray

Suggestion No. 2 by Andrew F. De Bernardi

(1) Suggestion No. 1 by H. A. Gray does not in

itself offer a definite plan for a transbay crossing, and for that reason

is not included among the 29 plans previously listed. The basic features

of the Gray suggestion contemplate the disengagement of commuter auto

traffic by the establishment of a complete rapid-transit train system

from San Francisco to the East Bay communities, and provision for better

distribution of auto traffic by elevated structures in the East Bay and

by subway system in San Francisco. The Gray suggestion would provide

a new bridge in a northerly location, and suggests a subterranean bus

terminal and auto parking garage under Telegraph Hill between Grant

Avenue and Stockton Street. The initial premise was to substitution of

rapid-transit trains to discourage commuter auto traffic is enlarged upon

in Appendix No. 9, Traffic Study.

(2) Suggestion No. 2 by Andrew F. De Bernardi

was a combination tube and subway from a terminal between Bay Street

and the San Francisco-San Mateo County line, and the vicinity of the

Ferry Bldg. The proposal would carry main-line trains operating on

a one per cent grade in a depressed roadway in the median of the subway-

way to a tube connection under navigable channels. Pedestrian traffic

would be carried on level lines outside of the depressed roadway in

decked on a steeper grade to continuous tubes. Total circulation

through the causeway would be provided by concrete ducts. No details or cost estimate were furnished. The suggestion did not provide enough detail to determine whether navigation clearances would be sufficient to answer the requirements of surface navigation. There is a serious doubt as to the adequacy of the concrete ducts to furnish necessary tidal circulation in view of the proposed depressed roadway. The main objections, from the standpoint of national interest, are that deep-water vessels utilizing the Oakland Inner Harbor would be required to take a circuitous route to reach the navigation channel traversed by the subaqueous tubes. In this connection, this plan is similar to Plan No. 25 by L. J. Nishkian discussed later.

(c) Continuous tube for Rapid Transit Studied by the Board.

(1) A comprehensive plan for a transbay rapid-transit system utilizing a continuous subaqueous tube has been given considerable study by the Board. The main features of this system would be as follows:

(a) A pair of single-track continuous tubes to carry electric rapid-transit trains from a location adjacent to the Southern Pacific Mole in Oakland to the foot of Howard Street in San Francisco.

(b) On the East Bay side, electric trains to serve this tube running on privately owned rights of way over substantially the present routes of the Key System with grades separated from vehicular traffic.

(c) Feeder bus lines to collect and distribute passengers for the East Bay lines.

through the machinery would be provided by concrete ducts. No details or cost estimates were furnished. The suggestion did not provide enough detail to determine whether navigation clearances would be sufficient to meet the requirements of surface navigation. There is a serious doubt as to the adequacy of the concrete ducts to furnish necessary vehicle orientation in view of the proposed depressed roadway. The main objections, from the standpoint of national interest, are that deep-water vessels utilizing the national inner harbor would be required to take a circuitous route to reach the navigation channel traversed by the subaqueous tube. In this connection, this plan is similar to Plan No. 23 by L. J. Hirschman discussed later.

(c) Continuous tube for Rapid Transit Studied by the Board.

(1) A comprehensive plan for a rapid transit system utilizing a continuous subaqueous tube has been given considerable study by the Board. The main features of this system would be as follows:

(a) A pair of single-track continuous tubes to carry electric rapid-transit trains from a location adjacent to the Southern Pacific Mole in Oakland to the foot of Howard Street in San Francisco.

(b) On the East Bay side, electric trains to move this tube running on privately owned rights of way over substantially the present route of the Key System with grades separated from vehicular traffic.

(c) Feeder bus lines to Oakland and distribution measures for the East Bay lines.

(d) A rapid-transit terminal in San Francisco in the vicinity of 6th and Howard Streets.

(e) A local subway loop or loops to collect and distribute passengers from the terminal to the central business district and adjacent areas.

(f) Provision for integrating (e) with a subway system to serve San Francisco and the Peninsula.

(2) This plan has been discussed more fully in Chapter XI. It is also discussed from a traffic viewpoint in Appendix No. 9, Traffic Study, and from a construction viewpoint in Appendix No. 12, Tube Studies.

(5) Combinations. The following five plans recommending various combinations of tubes and causeways as the solution to the transbay transportation problem were presented to the Board:

Plan No. 24 by Taggart Aston

Plan No. 25 by L. J. Nishkian

Plan No. 26 by F. E. Bonner

Plan No. 27 by Cleve F. Shaffer

Plan No. 28 by Loring P. Rixford

(a) Plan No. 24 by Taggart Aston. This plan would provide a floatable crib, railroad and highway bridge, and tunnel. The crossing would spring from Bryant Street, San Francisco, and land at Oakland Mole. It would provide a 1,500-foot navigation channel over the subaqueous tubes with a maximum depth of 45 feet at mean lower low water at the western end. This plan is subject to the objections discussed in Chapter IX. In addition, the following would tend to make

(d) A rapid-transit terminal in San Francisco in the vicinity of 5th and Howard Streets.

(e) A local subway loop or loops to collect and distribute passengers from the terminal to the central business district and adjacent areas.

(f) Provision for interurbanes (c) with a subway system to serve San Francisco and the Peninsula.

(g) This plan has been discussed more fully in Chapter XI. It is also discussed from a traffic viewpoint in Appendix No. 9, Traffic Study, and from a construction viewpoint in Appendix No. 12, Tube Studies.

(h) Combinations. The following five plans recommending various combinations of tubes and causeways as the solution to the transbay transportation problem were presented to the Board:

Plan No. 24 by Taggart Aston.

Plan No. 25 by L. J. Mitchell.

Plan No. 26 by T. E. Donner.

Plan No. 27 by Cleve F. Shaffer.

Plan No. 28 by Loring P. Rickford

(a) Plan No. 24 by Taggart Aston. This plan would provide a floatable arch, railroad and highway bridge, and tunnel. The crossing would spring from Bryant Street, San Francisco, and land at Oakland Mole. It would provide a 1,500-foot navigation channel over the submerged tubes with a maximum depth of 45 feet at mean lower low water at the western end. This plan is subject to the objections discussed in Chapter IX. In addition, the following would tend to make

the plan unacceptable:

(1) In foggy weather, the crossing would present an unacceptable obstruction and hazard to navigation for the great bulk of San Francisco Bay's water-borne traffic.

(2) In this area, a channel width of only 1,500 feet would not be sufficiently wide.

(3) Vessels from Oakland Outer Harbor and points north would be required to travel a considerable extra distance if bound to points within the Oakland Estuary.

(4) The channel depth should be 50 feet at mean lower low water instead of 45.

(b) Plan No. 25 by L. J. Nishkian.

(1) Mr. Nishkian collaborated in the Reber Plan. His own plan was the first phase of the Reber Plan and would provide for the construction of the proposed south mole. It would include a solid fill on an axis between Townsend Street, San Francisco, and the Oakland Mole with a ship channel 2,000 feet wide in an approximate north-south line about 5,000 feet long, located west of the western end of the Oakland Mole. No depth of water was indicated on the plan, but, as much of this channel at present is shoal water, it was assumed that the channel and approaches would be dredged to a minimum depth of 50 feet at mean lower low water. The entrance to the Oakland Estuary would be within the boundaries of the channel.

(2) This plan would reduce the tidal flow in front of the existing piers on the San Francisco side of the bay. This would result in silting of the natural channels and require continual dredging to keep them open. As discussed in Chapter IX, to be acceptable

the plan unacceptable:

(1) In foggy weather, the crossing would present an unacceptable obstruction and hazard to navigation for the great bulk of San Francisco Bay's water-borne traffic.

(2) In this area, a channel width of only 1,500 feet would not be sufficiently wide.

(3) Vessels from Oakland Outer Harbor and points north would be required to travel a considerable extra distance if bound to points within the Oakland Estuary.

(4) The channel depth should be 50 feet at mean lower low water instead of 45.

(b) Plan No. 25 by L. J. Markham

(1) Mr. Markham collaborated in the Harbor Plan. His own plan was the first phase of the Harbor Plan and would provide for the construction of the proposed south mole. It would include a solid fill on an axis between Townsend Street, San Francisco, and the Oakland Mole with a ship channel 2,000 feet wide in an approximate north-south line about 5,000 feet long, located west of the western end of the Oakland Mole. No depth of water was indicated on the plan; but, as much of this channel is present is shoal water, it was assumed that the channel and approaches would be dredged to a minimum depth of 50 feet at mean lower low water. The entrance to the Oakland Estuary would be within the boundaries of the channel.

(2) This plan would reduce the tidal flow in front of the existing piers on the San Francisco side of the bay. This would result in silting of the tidal channels and require continual dredging to keep them open. As discussed in Chapter IX, to be acceptable

at this location, a crossing of this type must provide a navigation channel on each side of the bay.

(3) Also, while the plan indicates that the velocity of the tidal flow in the single channel would be moderate or approximately 4 miles per hour, a Board study indicates a maximum tidal velocity of 7.3 for a tidal range of 4.3 feet, or an average velocity of 5.4 knots over the full tidal cycle. For a tidal range of 6.0 feet, the study indicated that the maximum velocity would reach 9.1 knots per hour with an average of 6.6 knots for the full tidal cycle. This tidal velocity would also substantially increase the tidal velocity in the Oakland Estuary. Not only would these excessive velocities be undesirable from the viewpoint of navigation, but the restrictions to tidal flow would render useless the comprehensive tidal movement data promulgated by the United States Coast and Geodetic Survey necessitating a complete re-study of tidal movement in the entire bay area.

(4) In addition, the following factors related to the plan are objectionable: All shipping bound to points south and east of the fill would be concentrated in the comparatively narrow channel in place of being able to operate as at present over the entire width of the harbor in this area. Involved in this considerable shipping are vessels bound to the many piers and shipyards, both naval and commercial, on the San Francisco water front, Oakland Inner Harbor, San Leandro Harbor, Redwood City, etc. With this heavy concentration of shipping, the chances of collision would be vastly increased, particularly during foggy and stormy weather.

at this location, a crossing of this type must provide a navigation channel on each side of the bay.

(3) Also, while the plan indicates that the velocity of the tidal flow in the single channel would be moderate or approximately 4 miles per hour, a Board study indicates a maximum tidal velocity of 7.3 for a tidal range of 4.3 feet, or an average velocity of 3.4 knots over the full tidal cycle. For a tidal range of 6.0 feet, the study indicated that the maximum velocity would reach 9.1 knots per hour with an average of 6.6 knots for the full tidal cycle. This tidal velocity would also substantially increase the tidal velocity in the Oakland Estuary. Not only would these excessive velocities be undesirable from the viewpoint of navigation, but the restrictions to tidal flow would render useless the comprehensive tidal movement data promulgated by the United States Coast and Geodetic Survey necessitating a complete re-study of tidal movement in the entire bay area.

(4) In addition, the following factors related to the plan are objectionable. All shipping bound to points north and east of the fill would be concentrated in the comparatively narrow channel in place of being able to operate as at present over the entire width of the harbor in this area. Involved in this considerable shipping are vessels bound to the many piers and shipyards, both naval and commercial, on the San Francisco water front, Oakland Inner Harbor, San Leandro Harbor, Redwood City, etc. With this heavy concentration of shipping, the chances of collision would be vastly increased, particularly during fogy and stormy weather.

(5) Large vessels destined to points within the Oakland Estuary with or without the aid of tugs, would require the entire width of the channel in which to maneuver, causing delays to other shipping. In addition, because of the rapid tidal velocity, these vessels would find it hazardous, if not impossible, to make the turn and enter the estuary except at slack water.

(6) From the figures on tidal velocity, it is obvious that low-powered vessels and tows would be restricted in their transit of the channel to a very short period of time around slack water.

(7) Hazards and interference with shipping would also result from lack of space for maneuvering between the fill, the piers of the Bay Bridge and Yerba Buena Island.

(8) Towage rates along the San Francisco water front would be increased considerably due to greatly increased distances involved and time consumed.

(9) In time of war, it would restrict rapid sortie of large numbers of naval vessels from the area south of the fill, particularly at night and under blackout conditions.

(10) Adoption of this plan would result in very high damage costs, and would render valueless large areas of fully developed water-front facilities.

(11) The State Board of Harbor Commissioners, in their public testimony, indicated that no need existed for the new facilities proposed as an integral portion of this plan, as extensive

(5) Large vessels docking to points within the Oakland Estuary with or without the aid of tugs, would require the entire width of the channel in which to maneuver, causing delays to other shipping. In addition, because of the rapid tidal velocity, these vessels would find it hazardous, if not impossible, to make the turn and enter the estuary except at slack water.

(6) From the figures on tidal velocity, it is obvious that low-powered vessels and tows would be restricted in their transit of the channel to a very short period of time around slack water.

(7) Hazards and interference with shipping would also result from lack of space for maneuvering between the fill, the piers of the Bay Bridge and Yerba Buena Island.

(8) Towage rates along the San Francisco water front would be increased considerably due to greatly increased distances involved and time consumed.

(9) In time of war, it would restrict rapid sortie of large numbers of naval vessels from the area south of the fill, particularly at night and under blackout conditions.

(10) Adoption of this plan would result in very high damage costs, and would render valuables large areas of fully developed water-front facilities.

(11) The State Board of Harbor Commissioners, in their public testimony, indicated that no need existed for the new facilities proposed as an integral portion of this plan, as extensive

areas are available for development into water-front facilities at less cost than these same facilities could be provided by the plan.

(12) There is no modification of this plan which can be made which would present a satisfactory solution in the alignment proposed.

(c) Plan No. 26 by F. E. Bonner.

(1) This plan proposed a combination causeway and tube between 16th Street, San Francisco, and Main Street, Alameda. It would consist of solid fill of 4,000 feet in length from the San Francisco side, a navigation channel over the subaqueous tube of 3,000 feet width, and a minimum depth of 48 feet at mean lower low water, then a solid fill to the Alameda shore.

(2) Tidal current charts of San Francisco Bay show a maximum normal tidal velocity of 2.2 knots per hour in this area. Due to the restriction to tidal flow offered by the solid mole, the author estimates that the current in the channel will be approximately 4.5 knots per hour. From information available, this appears to be a close approximation. This velocity presents no problem to shipping proceeding in the comparatively open water shown in the area indicated for the proposed channel. Only when maneuvering in congested waters and in approaching docks would this velocity be considered hazardous.

(3) The proposed channel depth should be slightly deeper than the proposed 48 feet as military and naval authorities require a minimum of 50 feet at mean lower low water.

(4) In the event that tidal velocity is considered excessive, the Bonner plan proposes an alternative by constructing the 4,000 foot section extending from the San Francisco shore

areas are available for development into water-front facilities at less cost than these same facilities could be provided by the plan.

(12) There is no modification of this plan which can be made which would produce a satisfactory solution to the alignment proposed.

(a) Plan No. 26 by J. E. Conner.

(1) This plan proposes a navigation channel and tube between 16th street, San Francisco, and Main Street, Alameda. It would consist of solid fill of 4,000 feet in length from the San Francisco side, a navigation channel over the mudflats 500 ft. 3,000 feet width, and a minimum depth of 24 feet at mean lower low water, then a solid fill to the Alameda shore.

(2) Tidal current charts of San Francisco Bay show a maximum normal tidal velocity of 4.5 knots per hour in this area. Due to the restriction to tidal flow effected by the solid fill, the author estimates that the current in the channel will be approximately 4.5 knots per hour. From inform ation available, this appears to be a close approximation. This velocity presents no problem to shipping proceeding in the comparatively open water shown in the area indicated for the proposed channel. Only when maneuvering in congested waters and in docking docks would tidal velocity be considered a factor.

(3) The proposed channel depth should be slightly deeper than the proposed 24 feet as shifting with tidal conditions requires a minimum of 30 feet at mean lower low water.

(4) In the event that tidal velocity is considered excessive, the Bonner plan proposes an alternative by constructing the 4,000 foot section extending from the San Francisco shore

as a low-level bridge instead of a solid fill. This would reduce considerably the tidal velocity in the proposed channel.

(5) The plan and the alignment proposed would interfere with seaplane operations from the Alameda Naval Air Station. The east mole crosses the seaplane operating area and interferes with both the east-west and north-south take-off areas.

(d) Plan No. 27 by Cleve F. Shaffer.

(1) This plan proposed a combination tube, floating bridge and trestle between 2nd Street, San Francisco, and an undisclosed point in Alameda which appears to be at the Alameda Naval Air Station. It would consist of tubes approximately 3,000 feet long from the San Francisco shore connecting with a floating bridge 7,200 feet long followed by 6,000 feet of trestle connecting the Alameda shore. Within the 3,000-foot width above the subaqueous tubes would be a 1,000-foot channel with a depth of 40 feet for large vessels, and two 500-foot channels with a depth of 20 feet for smaller craft; one on either side of the saddle towers used for ventilation. The towers would mark the extremities of the 1,000-foot channel.

(2) This plan is not considered acceptable for the following reasons:

(a) A channel only 1,000 feet wide would not be practical in this location because of the comparatively large volume of water-borne traffic in this area. The concentration of shipping would cause delays and the chances of collision, particularly in foggy weather, would be greatly increased.

(b) The eastern terminus is not defined but it appears that it would pass through the center of Alameda Naval

as a low-level bridge instead of a solid fill. This would reduce considerably the tidal velocity in the proposed channel.

(c) The plan and the alignment proposed would interfere with seaplane operations from the Alameda Naval Air Station. The east mole crosses the seaplane operating area and interferes with both the east-west and north-south take-off areas.

(d) Plan No. 27 by Cleve T. Shaffer.

(1) This plan proposed a combination tube, floating bridge and trestle between 2nd Street, San Francisco, and an undisclosed point in Alameda which appears to be at the Alameda Naval Air Station. It would consist of tubes approximately 2,000 feet long from the San Francisco shore connecting with a floating bridge 7,200 feet long followed by 6,000 feet of trestle connecting the Alameda shore. Within the 2,000-foot width above the subaqueous tube would be a 1,000-foot channel with a depth of 40 feet for large vessels, and two 500-foot channels with a depth of 20 feet for smaller craft; one on either side of the middle towers used for ventilation. The towers would mark the extremities of the 1,000-foot channel.

(2) This plan is not considered acceptable for the following reasons:

(a) A channel only 1,000 feet wide would not be practical in this location because of the comparatively large volume of water-borne traffic in this area. The concentration of shipping would cause delays and the chances of collision, particularly in foggy weather, would be greatly increased.

(b) The eastern terminus is not defined but it appears that it would pass through the center of Alameda Naval

Air Station. This location would seriously interfere with the operation of large aircraft carriers going to and from the Alameda Naval Air Station since the proposed trestle would parallel, and be close to, the channel at the entrance to the station. This location would also seriously interfere with the station's seaplane operations.

(c) In time of war, it would restrict rapid sortie of large numbers of naval vessels from the area south of the proposed location, particularly at night and under blackout conditions.

(e) Plan No. 28 by Loring P. Rixford.

(1) This plan proposed a combination mole and tube between Townsend Street, San Francisco, and landing in the northwest corner of the Alameda Naval Air Station. It would consist of 6,840 feet of solid mole from the San Francisco side, with facilities provided for the berthing of ships, a 6,690-foot navigation channel of undisclosed depth over the subaqueous tube and the remainder a solid mole to the Alameda shore with facilities provided for the berthing of ships. It proposed to cross the Oakland Estuary with an additional tube, come to the surface, and cut across the Naval Supply Depot, Oakland residential property, Oakland Army Base, etc.

(2) The plan contained in Appendix No. 8 is a sketch giving very meager information with no accompanying literature. From the limited details available, the plan appears impractical, particularly from the standpoint of tremendous costs involved.

(3) In addition, the plan is not considered feasible for the following reasons:

Air Station. This location would seriously interfere with the operation of large aircraft carriers going to and from the Alameda Naval Air Station since the proposed trestle would parallel, and be close to, the channel at the entrance to the station. This location would also seriously interfere with the station's seaplane operations.

(c) In time of war, it would restrict rapid sortie of large numbers of naval vessels from the area south of the proposed location, particularly at night and under blackout conditions.

(e) Plan No. 28 by Lorine E. Bickford.

(1) This plan proposed a combination mole and tube between Doolittle Street, San Francisco, and landing in the northwest corner of the Alameda Naval Air Station. It would consist of 6,840 feet of solid mole from the San Francisco side, with facilities provided for the berthing of ships, a 6,690-foot navigation channel of undisclosed depth over the subjacent tube and the remainder a solid mole to the Alameda shore with facilities provided for the berthing of ships. It proposed to cross the Oakland Estuary with an additional tube, come to the surface, and cut across the Naval Supply Depot, Oakland residential property, Oakland Army Base, etc.

(2) The plan contained in Appendix No. 8 is a sketch giving very scanty information with no accompanying literature. From the limited details available, the plan appears impractical, particularly from the standpoint of tremendous costs involved.

(3) In addition, the plan is not considered feasible for the following reasons:

(a) It would interfere with flight operations at Alameda Naval Air Station and with the proposed extension of the runways.

(b) The approaches to the Oakland Estuary tube would cross the Oakland Naval Supply Depot and Oakland Army Base. These bases were constructed at tremendous cost, and interference with these activities would not be acceptable.

(c) The plan as proposed, would increase the tidal velocities to the detriment of shipping. It would reduce the tidal prism, and by virtue of the mole construction would undoubtedly cause shoaling in the vicinity of existing waterfront facilities and existing channels.

(d) In foggy weather it would present an unacceptable hazard to navigation for a large part of San Francisco Bay's water-borne traffic.

(f) Joint Board's Combination Causeway and Tube.

(1) After careful consideration of all the factors involved, the Board felt that it should offer a combination causeway-tube solution to the transbay transportation problem, which would more fully satisfy the accepted criteria. Engineering details, cost data,etc. are submitted in Appendix #12 (b). It proposes a location at Army Street, San Francisco, to Fifth Street, Alameda. The crossing would consist of a trestle causeway of about 3,575 feet springing from the San Francisco side, tubes about 6,400 feet in length, a 1,500 foot navigation channel with a minimum depth of 50 feet at MLLW as part of a clear width of approximately 4,000 feet of open water between ventilating towers over the subaqueous tubes, a trestle

(a) It would interfere with flight operations at Alameda Naval Air Station and with the proposed extension of the runways.

(b) The approaches to the Oakland Estuary tube would cross the Oakland Naval Supply Depot and Oakland Army Base. These areas were constructed at tremendous cost, and interference with these activities would not be acceptable.

(c) The plan as proposed, would increase the tidal velocities to the detriment of shipping. It would reduce the tidal prism, and by virtue of the mole construction would undoubtedly cause shoaling in the vicinity of existing waterfront facilities and existing channels.

(d) In foggy weather it would present an unacceptable hazard to navigation for a large part of San Francisco Bay's water-borne traffic.

(f) Joint Board's Combination Causeway and Tube.

(1) After careful consideration of all the factors involved, the Board felt that it should offer a combination causeway-tube solution to the transbay transportation problem, which would more fully satisfy the accepted criteria. Engineering details, cost data, etc. are submitted in Appendix #12 (b). It proposes a location at Army Street, San Francisco, to Fifth Street, Alameda. The crossing would consist of a tunnel causeway of about 3,575 feet springing from the San Francisco side, tubes about 6,400 feet in length, a 1,500 foot navigation channel with a minimum depth of 50 feet at MLLW as part of a clear width of approximately 4,000 feet of open water between ventilating towers over the subaqueous tubes, a tunnel

causeway of about 14,845 feet followed by 7,132 feet of solid mole landing on the Alameda shore.

(2) This plan would satisfy the first three criteria of the Board exceptionally well. With a modification of the present seaplane operating area it would satisfy Criteria #4 during normal operating conditions. This modification requires extension of the seaplane operating area northward to the southern edge of the Oakland Fairway and making available the seadrome facilities of the San Francisco Airport for emergency use by dredging existing runways and channels to a 15-foot depth.

d. Solutions selected for detailed study.

After considering all plans in the light of the criteria adopted by it, the Board concluded that the plans which satisfied its criteria best and which warranted further detailed study were the following:

(1) State of California's high-level bridges from Telegraph Hill to the Key Mole.

(2) State of California's high-level bridge from Rincon Hill to Key Mole (parallel structure).

(3) The Board's adaptation of the combination causeway tube.

For the purpose of this detailed study and comparison the proposed high-level bridges at Telegraph Hill will be grouped and referred to as the North crossing. The high level bridge at Rincon Hill will be called the Central crossing and the combination causeway tube from Army Street will be named the South crossing.

XIII. COMPARISON OF SELECTED SOLUTIONS

A. Comparison from the Standpoint of Adequacy.

1. General. An additional bay crossing for auto vehicular traffic should adequately and economically provide a substantial portion of the automotive commuter traffic with a fast route between the centers of demand on either side of the bay, not necessarily the one most direct.

2. In arriving at the relative adequacy of the different selected solutions, consideration was given to the degree to which each would meet the criteria adopted by the Board. The following discussion compares the relative adequacy of the selected solutions, and then examines the economics of each. The data on which this discussion is based may be found in detail in Appendix No. 9.

B. Relative Adequacy.

1. This comparison is a study of the relative ability of the selected solutions to meet the peak-hour demands, that is, to enable peak-hour commuters to reach the central business district of San Francisco from their homes on the East side of the bay in the morning in a minimum of time, without undue difficulty, and to return to them expeditiously after business hours in the evening. If the selected solutions meet this requirement, there is little problem to meeting the demands of the other hours of the day.

2. It is recognized that the central business district cannot handle the ultimate volume of traffic that would be introduced by a second vehicular crossing and that, regardless of where the next crossing is located, it should be supplemented by peripheral parking facilities sufficiently adequate to absorb a large portion of the bridge traffic before it enters the central business district.

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2. It is recognized that the central business district cannot handle the ultimate volume of traffic that would be introduced by a second vehicular crossing and that, regardless of where the next crossing is located, it should be supplemented by peripheral parking facilities sufficiently adequate to absorb a large portion of the bridge traffic before it enters the central business district.

Therefore, this study is limited to a comparison of the ability with which terminal areas of the selected crossings can bring the traffic to the boundary of the central business district, and does not concern itself with the ability of the district to absorb the traffic.

3. At the present time, in the central eastern section of San Francisco into which a south crossing would discharge, only two main thoroughfares are available for any traffic to travel between Army Street and Brannan Street. These streets are Potrero Avenue and 3d Street. They now bear a very large portion of the heavy peninsula traffic and are very congested during peak hours. The Bayshore Freeway, when constructed, will relieve this congestion to some extent but will provide insufficient additional capacity for the use of traffic using a south crossing. Therefore, a freeway for bringing such cross-bay traffic from Army Street to and beyond the Southern Pacific and other railroad tracks south of Townsend Street and dispersing it properly before it reaches the central business district should be provided. Without such a freeway, a south crossing would not adequately relieve the transbay traffic problem during peak hours.

4. It is assumed that adequate distribution facilities would be provided for each crossing and that traffic laws necessary to insure easy and rapid flow of traffic on the critical streets in the terminal areas of each crossing would be passed and enforced.

5. To serve the present pattern of traffic reasonably well, the crossing should, naturally, attract a reasonable percentage of the present total volume of traffic and, to provide for probable future

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3. At the present time, in the central business district of San Francisco into which a south crossing would discharge, only two main thoroughfares are available for any traffic to travel between Army Street and Bryant Street. These arteries are Potrero Avenue and 3d Street. They can bear a very large portion of the heavy peninsula traffic and are very congested during peak hours. The Bayshore Freeway, when constructed, will relieve this congestion to some extent but will provide insufficient additional capacity for the use of traffic using a south crossing. Therefore, a freeway for bringing such cross-bay traffic from Army Street to and beyond the Southern Pacific and other railroad tracks south of Townsend Street and dispersing it properly before it reaches the central business district should be provided. Without such a freeway, a south crossing would not adequately relieve the transbay traffic problem during peak hours.

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5. To serve the present pattern of traffic reasonably well, the crossing should, naturally, attract a reasonable percentage of the present total volume of traffic and, to provide for probable future

traffic, it should not cause undue inconvenience to the total portion of traffic it would probably be called on to serve.

6. Under the present conditions, all the selected crossings would serve the present pattern of traffic reasonably well. The north and south locations would inconvenience more traffic than would a Central location, but the percentage of traffic inconvenienced and the extent of inconvenience would both be small. All the solutions under consideration would provide a reasonably adequate crossing for auto vehicular traffic and are considered to satisfy this criterion equally well.

7. To provide easy and rapid dispersion of traffic, the terminal areas of the selected crossings should permit ready distribution, should not be overly congested and should be reasonably close to the center of the demand.

8. On the San Francisco side of the bay, assuming that proper connecting facilities were provided for a south crossing, a central and a south crossing would distribute peak-hour traffic over identical streets. Both of them would discharge the traffic into streets having greater excess capacity now than those into which a north crossing would discharge. In addition, they would provide a better general dispersion pattern since they would distribute the traffic entering the central business district over a broader front than would a north crossing.

9. However, the approach streets for a central and a south crossing would probably become critically congested sooner than those for a north crossing, although the congestion would be about the same for all crossings at the time the existing bridge will probably again become congested.

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7. To provide easy and rapid dispersion of traffic, the terminal areas of the selected crossings should permit rapid distribution, should not be overly congested and should be reasonably close to the center of the demand.

8. On the San Francisco side of the bay, assuming that proper connecting facilities were provided for a north crossing, a central and a south crossing would distribute peak-hour traffic over identical routes. Both of them would discharge the traffic into streets having greater excess capacity now than those into which a north crossing would discharge. In addition, they would provide a better general dispersion pattern since they would distribute the traffic entering the central business district over a broader front than would a north crossing.

9. However, the approach streets for a central and a south crossing would probably become materially congested sooner than those for a north crossing, although the congestion would be about the same for all crossings at the time the westbound bridge will probably begin become congested.

10. A central crossing would be located closest to the center of demand, as it would be only a half mile distant. A north crossing would be three quarters of a mile distant and a south crossing the most distant, a little over two and a half miles away.

11. On the east side of the bay, both terminal areas would provide comparable facilities for the dispersion of the traffic. In this connection, it is assumed that adequate tubes under the Oakland Estuary would be provided for a south crossing as called for in the plan for that crossing.

12. The factor that concentrates traffic on the east side of the bay and results in congestion is the present bridge, toward which focal point all the traffic must move to cross the bay. To place a second structure adjacent to the existing bridge would increase this concentration and congestion, whereas a crossing somewhat removed from the present bridge should spread the traffic and reduce the congestion.

13. On the east side of the bay the terminal distribution structure of a north or central crossing would be three quarters of a mile closer to the center of demand of the area it would serve, namely, the entire East Bay area, than would the entrance to the estuary tubes of a south crossing from the center of demand of the area it would serve, namely, the south half of the east bay area of demand.

14. From the foregoing, it is concluded that a south crossing would serve the present pattern of traffic reasonably well and would discharge traffic into areas providing the easiest and most rapid dispersion of traffic.

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15. National interests are considered from two points of view--navigation and national defense.

16. With respect to navigation, no crossing should be approved which materially affects the hydraulic characteristics of the bay or of the entrance to the bay, or which denies the use of, or materially reduces, the operating efficiency of any existing or proposed harbor facilities.

17. Since a north crossing would be a high-level bridge, it would not affect the hydraulic characteristics of the bay, nor of the entrance to the bay, and would not interfere with existing anchorage areas. The bridge piers would offer practically the same obstructions to water-borne traffic as those the present bridge created when it was constructed, and, therefore, the existing hazards to navigation would be doubled west of Yerba Buena Island. Under this structure, over 80 per cent of the water-borne traffic of the bay area would be required to pass to reach its destination.

18. The above comments, with respect to hydraulic characteristics and anchorages, apply equally to a central crossing. Here a high-level bridge parallel to and close to the present crossing offers practically no additional hazards to the shipping that would be required to pass under it. This is estimated to be in excess of 42 per cent of the bay area's water-borne traffic.

19. A combination open causeway-tube as a south crossing would not affect the hydraulic characteristics of the entrance to San Francisco Bay, neither would the minor obstruction to tidal flow presented by the islands in which the tube would come to grade appreciably affect the

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19. A combination open causeway-tube as a south crossing would not affect the hydraulic characteristics of the entrance to San Francisco Bay, neither would the minor obstruction to tidal flow presented by the islands in which the tube would come to grade appreciably affect the

hydraulic character of the lower bay. The crossing would interfere with existing anchorages, but the interference could be adjusted without affecting navigation by shifting the anchorage area. Due to its location in the south bay, it is estimated that only 11 per cent of commercial shipping would find it necessary to pass this crossing to arrive at its destination.

20. With respect to national defense, no crossing should be approved which would materially reduce the operating efficiency of any existing or proposed military or naval facility.

21. The Commander, Western Sea Frontier, considers the crossings desirable in the following order, the most desirable being listed first: south crossing, north or central crossing. The Commanding General, Sixth Army, prefers the crossings in the order north, central, south, primarily because in that order they provide most direct communication between the Port of Embarkation at Oakland and the Army installations on the west side of the bay.

22. From the viewpoint of national defense, therefore, there is little to choose from between the north and central crossings. Both would interfere to some extent with national interests and operations on Yerba Buena Island and both are vulnerable to common damage by a single bomb hit, particularly the central crossing. However, neither interferes with land or seaplane operations.

23. An open causeway-tube as a south crossing would not create an objectionable hazard to surface navigation and could be so located and designed that it would not interfere with land or seaplane operations.

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23. An open causeway-type as a south crossing would not create an objectionable hazard to surface navigation and could be so located and designed that it would not interfere with land or seaplane operations.

A crossing in this location would disperse the bay crossing facilities, thereby reducing their vulnerability to common damage by a single bombing attack.

24. Therefore, from the standpoint of national interests, of the solutions under consideration, a south crossing is the most adequate and a central crossing is more adequate than a north crossing.

25. A major consideration with respect to any crossing would be its role as an appropriate component of an overall general plan providing for cross-bay traffic over an extended period of years. Such a plan to solve the cross-bay transportation problem can be developed according to either one of two principles: By decreasing the demand for auto vehicular crossing facilities, or by constructing additional crossings for auto vehicular traffic as the need becomes apparent.

26. The downtown streets of San Francisco are very congested at present and to introduce more traffic into this area would be unwise. Therefore, the ideal would be a solution of the cross-bay transportation problem in accordance with the first principle, that of decreasing the demand for auto vehicular crossing facilities. However, since the present local trend is away from train commuting to more commuting by private automobile, it appears that the commuting public using the San Francisco-Oakland Bay Bridge would not be encouraged to change its travelling habits to mass transportation, until suitable and completely integrated rapid-transit facilities are provided for the East Bay communities and in San Francisco. The Board considers that, for this purpose, a continuous subaqueous tube located near the line of the present bridge, designed to carry rapid-transit facilities only, would provide the best crossing for this phase of an overall general plan. However, construction of

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the tube is not recommended at this time, as the immediate need is relief for transbay automobile vehicular traffic (including trucks and buses). Ultimately, however, congestion on the streets of San Francisco will force the bay area to accept mass transportation, and any long-range plan should recognize this eventuality.

27. Since it is impracticable, if not impossible, to provide a single acceptable type of crossing which will meet the necessity of, and the desires for, automotive vehicular and interurban and/or main-line railroad traffic, the overall long-range plan should not include provisions for such main-line railroad facilities. Until the bringing of main-line railroad traffic into San Francisco is shown to be economically justified, the overall long-range plan should provide only facilities for mass transportation, such as a continuous subaqueous tube for electric railway completely integrated with complementary rapid-transit facilities in the terminal communities, as well as one or more crossings for automotive vehicular traffic with adequate termini distribution facilities.

28. Vehicular crossing facilities can be located according to one of two principles: Either by providing a crossing which will directly connect the centers of demand of the total area on each side of the bay, or by dividing the areas of demand on either side of the bay into equal parts so that the present bridge connects the centers of demand of one of these parts on each side of the bay, and the proposed crossing or crossings, each connect the remaining pair, or pairs, of areas. In either case, when congestion again demands relief, the choice for a third crossing must again be made between a continuous tube for rapid-transit facilities and an additional vehicular crossing facility.

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29. A crossing located in accordance with the first principle concentrates traffic and fosters congestion to an undesirable degree. A long-range plan for the solution of the cross-bay transportation problem should, therefore, be based on the second principle. Since this decision, in effect, eliminates a central crossing, under this consideration the choice must now be made between the north and the south crossing. If the areas of demand on either side of the bay are divided into halves, a south crossing would combine with a central better to serve a half of the demand better than would a north crossing. In addition, if a third vehicular crossing is built in the future, a south crossing would also combine better with it and the existing bridge to provide a balanced group of vehicular crossing facilities than would a north crossing along the line now proposed. On the basis of this and other data submitted to the Board, particularly because a south crossing would result in less congestion, provide a more flexible component of an overall general plan, be less vulnerable to common damage and afford better opportunities for parking areas, a south location for the next crossing is the more suitable solution to the present problem.

30. The City of San Francisco expressed a strong desire at the public hearings for a crossing south of the existing bridge. Its plea was based on its belief that such a location would stimulate the commercial and residential growth of the city by inducing expansion away from the present area of congestion. San Francisco further expressed a desire for bringing main- line railroad trains into the city. It would not be practical to bring them in over a north or a central location since both of these involve a high-level bridge, and, therefore, only a south location offers any possibility at all in this respect.

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31. The City of Alameda felt that it should receive special consideration, pointing out that it had not received the same advantages from the present bridge as did other parts of the area and that present commuter facilities are inferior to the previous ferry service which was discontinued when the bridge went into operation.

C. Discussion from the Standpoint of Economics. A detailed economic study of the selected solutions was made and is submitted, in its entirety, in Appendix No. 9, II, (a) (2). This discussion is a summary of the conclusions arrived at in that study, including a tabulation of the critical data. The items listed in the latter include the following:

1. Construction Cost. Includes all construction costs (except those for the connecting freeway on the San Francisco side for a south crossing), engineering, real estate, and interest during construction.

2. Total Cost to Amortize. Includes the costs for use and occupancy insurance, fees and expenses of fiscal and other agents, annual expenses for operation and maintenance and interest charges.

3. Reduction in Tax Rolls. Includes the losses from tax income to the different communities for the period of amortization only.

4. Income from Generated Traffic. Was credited to the south crossing only on the assumptions that:

a. A central crossing, being essentially an expansion of the existing bridge, would generate no traffic.

b. A north crossing, being common to the existing bridge at its east end and discharging close to the existing bridge at its west end, would generate an amount of traffic small enough to be disregarded for the purpose of this discussion.

c. A south crossing, on the basis of the figures on generated traffic in the Board's study, would generate at least a 10 per cent

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C. Discussion from the standpoint of Economics. A detailed economic study of the proposed locations was made and is submitted, in its entirety, in Appendix No. 9, II, (a) (4). This discussion is a summary of the conclusions arrived at in that study, including a tabulation of the critical data. The items listed in the letter include the following:

1. Construction Cost. Includes all construction costs (except those for the connecting freeway on the San Francisco side for a south crossing), engineering, real estate, and interest during construction.

2. Total Cost to Amortize. Includes the costs for use and occupancy insurance, fees and expenses of legal and other agents, annual expenses for operation and maintenance and interest charges.

3. Reduction in Tax Rolls. Includes the losses from tax income to the different communities for the period of amortization only.

4. Income from Generated Traffic. When credited to the north crossing only on the assumptions that:

a. A central crossing, being essentially an extension of the existing bridge, would generate no traffic.

b. A north crossing, being opposite to the existing bridge at its east end and discharging close to the existing bridge at its west end, would generate an amount of traffic small enough to be disregarded for the purpose of this discussion.

c. A south crossing, on the basis of the figures generated traffic in the Board's study, would generate at least a 10 per cent

increase in traffic.

	North	Central	South
Construction - Crossing Proper	$ 75,371,600	$ 74,791,000	$ 76,525,000
Approaches - S.F.	11,224,000	5,861,000	5,400,000
East Bay (including estuary tubes)	8,061,000	7,595,000	24,293,000
Engineering	4,732,000	4,420,000	5,310,000
Real Estate	27,993,000	19,680,000	16,605,000
Miscellaneous	6,267,400	5,563,000	6,335,000
Total Initial Cost	$133,649,000	$117,910,000	$134,468,000
Total Cost to Amortize	272,000,000	226,000,000	271,000,000*
Year Amortized	1981	1977	1979**
Reduction in Tax Rolls			
San Francisco	416,000	277,000	111,000
Oakland	48,000	48,000	98,000
Alameda	---	---	11,000
Total per Year	464,000	325,000	220,000
For Years	33	29	31
Total Tax Loss	15,312,000	9,425,000	6,820,000
Overall Total Costs	287,312,000	235,425,000	277,820,000
Income from Generated Traffic 625,000/yr for 27 years	0	0	16,875,000
Total Grand Cost (Round figures)	$287,000,000	$235,000,000	$261,000,000

*Reduced by $3,000,000 from the value obtained by the use of Chart, Appendix 9 II, as a conservative estimate of cost reduction due to shorter period of construction.

**Reduced by two years due to shorter period of construction.

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	North	Central	South
Construction - Crossing Proper	$ 75,371,600	$ 34,781,000	$ 76,925,600
Approaches - S.F.	11,224,000	5,661,000	5,400,000
Yerba Buena (including auxiliary tubes)	5,061,000	7,595,000	24,229,000
Engineering	4,724,000	4,420,000	5,316,000
Real Estate	27,993,000	19,580,000	15,505,000
Miscellaneous	6,267,400	5,753,000	6,225,000
Total Initial Cost	$132,649,000	$112,010,000	$134,468,000
Total Cost to Amortize	372,000,000	226,000,000	271,000,000*
Year Amortized	1981	1977	1979**
Reduction in Tax Rolls			
San Francisco	416,000	277,000	111,000
Oakland	48,000	48,000	95,000
Alameda	---	---	11,000
Total per Year	464,000	325,000	206,000
For Years	34	29	31
Total Tax Loss	15,776,000	9,425,000	6,320,000
Overall Total Costs	287,312,000	236,425,000	277,840,000
Income from Generated Traffic $625,000/yr for 27 years	0	0	16,875,000
Total Grand Cost (Round Figures)	$287,000,000	$236,000,000	$261,000,000

*Reduced by $3,000,000 from the value obtained by the use of Chart, Appendix 9 II, as a conservative estimate of cost reduction due to shorter period of construction.

**Reduced by two years due to shorter period of construction.

5. The Board study indicated that the cost of operation of a causeway-tube would be greater than that of a bridge. However, the maintenance costs would be so much lower that the combined operation and maintenance costs of a causeway-tube would be lower than those of a bridge. These costs were assumed to be equal at $750,000 per year.

6. If a crossing is constructed at a South location, a freeway for bringing cross-bay traffic north from Army Street, to and beyond the Southern Pacific, and other railroad tracks south of Townsend Street, and dispersing it properly should be provided. Therefore, the cost of construction of such a freeway, $26,134,000, and the reduction in San Francisco tax rolls, $222,000 per year, although not included in the cost of the crossing, have been determined and included in detail in Appendix #9.

7. The intangible economic benefits did not lend themselves to monetary evaluation and were therefore not included in the tabulation (they are, however, discussed in the same Appendix). Of particular note is the depreciation in land values caused by a high-level bridge at a North and Central location as compared to the increase in land values a causeway-tube would create at a South location. The advantages of a South crossing in this regard are summarized briefly as follows:

a. Is an appropriate component of an overall general plan.

b. Creates less congestion.

c. Provides bay crossing facilities less vulnerable in time of war.

d. Coincides with the Plan of the City of San Francisco.

5. The Bond study indicated that the cost of operation of a causeway-tube would be greater than that of a bridge. However, the maintenance costs would be so much lower that the combined operation and maintenance costs of a causeway-tube would be lower than those of a bridge. These costs were assumed to be equal at $750,000 per year.

6. If a crossing is constructed at a South location, a freeway for bringing cross-bay traffic north from Army Street, to and beyond the Southern Pacific, and other railroad tracks south of Townsend Street, and disposing it properly should be provided. Therefore, the cost of construction of such a freeway, $26,134,000, and the reduction in San Francisco tax rolls, $222,000 per year, although not included in the cost of the crossing, have been determined and included in detail in Appendix "C".

7. The intangible economic benefits did not lend themselves to monetary evaluation and were therefore not included in the tabulation (they are, however, discussed in the same Appendix). Of particular note is the depreciation in land values caused by a high-level bridge at a North and Central location as compared to the increase in land values a causeway-tube would create at a South location. The advantages of a South crossing in this regard are summarized briefly as follows:

a. Is an appropriate component of an overall general plan.

b. Creates less congestion.

c. Provides bay crossing facilities less vulnerable in time of war.

d. Delineates with the Ferry of the City of San Francisco.

e. Provides relief for the City of Alameda.

f. Is the only acceptable solution that provides any possibility at all of future expansion to include railroads.

g. Permits more flexible construction.

h. Results in overall appreciation rather than depreciation of real property.

i. Permits earlier completion.

j. Rate of depreciation of structure is lower.

k. Permits use of cheaper property if peripheral parking is provided remote from the central business district of San Francisco.

8. The Board concludes that, while the tangible economic considerations favor a central crossing, the intangible economic benefits which would accrue through the construction of a south crossing greatly outweigh the tangible benefits of a central crossing.